HYGIENE FOR STUDENTS AND TEACHERS

A HANDBOOK OF
HYGIENE
FOR STUDENTS AND TEACHERS

BY

CYRIL G. EASTWOOD

B.Sc., M.B., Ch.B. (Manch.), M.R.C.S. (Eng.), L.R.C.P. (Lond.), D.P.H. (Leeds)

Assistant Medical Officer of Health, Borough of Worthing; formerly Lecturer in Hygiene and Physiology in the University of Leeds; sometime Worswick Fellow of the University of Manchester

LONDON

EDWARD ARNOLD & CO.

1936

TO

MY WIFE

WITHOUT WHOSE

CONSTANT ENCOURAGEMENT

AND ASSISTANCE THIS BOOK

WOULD NOT HAVE BEEN

WRITTEN

MADE AND PRINTED IN GREAT BRITAIN
AT THE UNIVERSITY PRESS, ABERDEEN

PREFACE

THIS book is based upon courses of lectures in elementary physiology and hygiene which I gave for some years in the Education Department of the University of Leeds and at the City of Leeds Training College. There are, of course, a number of books dealing with these subjects, but those with which I am acquainted do not combine physiology and hygiene in proportions suitable for the average student's needs. The teacher needs to practise the principles of hygiene, and for the proper understanding of these a foundation of physiological knowledge is necessary. If, however, the physiology is limited to a bare minimum, hardly sufficient to explain the hygiene, the student is likely to be left in a dangerous state of partial comprehension. On the other hand, if a sound physiological basis is laid, much of the hygiene becomes self-evident and easily comprehensible even without formal instruction. For this reason I have maintained a physiological approach throughout the book and adopted the arrangement of matter which is explained in the introductory chapter.

Nevertheless, I have endeavoured to avoid the other extreme, and have only introduced such physiological topics as seemed essential to a proper understanding of the working of the body. I thought it better to omit some things entirely rather than to give them incomplete treatment which would merely introduce additional complications and raise unanswered questions in the reader's

mind. With the same object in view, very simple diagrams have been used rather than complex figures from anatomical textbooks as these often confuse rather than elucidate.

A particular feature is the relationship between the text and the figures and tables. These are not mere illustrations of the printed word. On the contrary, the diagrams are the primary things and the text simply elaborates upon and explains them. It is hoped that this method of presentation will successfully imitate the best features of the spoken lecture, and the book should be used with this in mind.

A few of the illustrations have been borrowed from other publications, and I wish to thank those authors and publishers who have kindly lent me blocks and photographs; a full acknowledgment is given under these figures. My thanks are also due to many friends for advice and assistance: in particular to Dr. Stockwell, School Medical Officer of Leeds, who has given me free access to the work of his department, and to my former colleague, Dr. Dangerfield, who has read the proofs.

C. G. E.

CONTENTS

CHAPTER		PAGE
1.	INTRODUCTION: THE PLAN OF THIS BOOK	1

PART I

BIOLOGICAL AND PHYSIOLOGICAL FOUNDATIONS

2.	THE NATURE AND CHARACTERISTICS OF LIVING CREATURES	3
3.	THE SKELETON	13
4.	THE MUSCLES .	27
5.	THE BLOOD AND CIRCULATION .	36
6.	BREATHING . .	48
7.	THE DIGESTION OF FOOD .	60
8.	THE EXCRETION OF WASTE PRODUCTS	74
9.	THE NERVOUS SYSTEM .	80
10.	THE ENDOCRINE ORGANS	101
11.	REPRODUCTION	106
12.	THE BODY AS A WHOLE. GROWTH AND DEVELOPMENT	111

PART II

NUTRITION AND DIETETICS

13.	FOOD .	117
14.	BEVERAGES . .	127
15.	THE FEEDING OF SCHOOL CHILDREN	138
16.	MALNUTRITION	147

PART III

HYGIENE OF CHILDREN

17.	GENERAL PERSONAL HYGIENE .	154
18.	WARMTH, CLOTHING AND FOOTWEAR . .	160
19.	POSTURE, EXERCISE, FATIGUE, REST AND SLEEP	165

CHAPTER PAGE

20. THE EYE AND VISION:
    Structure . 174
    Function . 184
    Hygiene 187
    Disorders 193
    Education of Children with Defective Vision 198

21. THE EAR AND HEARING:
    Structure . 202
    Function . 205
    Hygiene . 209
    Disorders 212
    Education of Children with Defective Hearing 216

22. THE TEETH:
    Structure and Development 218
    Hygiene . . . 223
    Diseases and Prevention 228

PART IV
DISEASES OF CHILDREN

23. CHILDREN'S DISEASES: INTRODUCTORY AND GENERAL 233
24. INFECTIOUS FEVERS 241
25. TUBERCULOSIS AND RHEUMATISM 257
26. SKIN DISEASES . 265
27. OTHER PARASITIC DISEASES . 272
28. HYSTERIA, EPILEPSY AND STAMMERING 275
29. ACCIDENTS AND EMERGENCIES . 280

PART V
HYGIENE OF THE SCHOOL

30. SCHOOL BUILDINGS AND EQUIPMENT 294
31. VENTILATION, HEATING AND LIGHTING 300
32. SPECIAL SCHOOLS AND SPECIAL EDUCATION 311
33. THE SCHOOL MEDICAL SERVICE AND OTHER AGENCIES FOR CHILD HEALTH 321

PART VI
HYGIENE AND EDUCATION

34. HEREDITY . 328
35. THE TEACHING OF HYGIENE 331
36. THE LAW RELATING TO SCHOOL CHILDREN 336

VOCABULARY OF TECHNICAL TERMS 340

INDEX 349

CHAPTER 1

INTRODUCTION: THE PLAN OF THIS BOOK

Hygiene is the art of looking after the human body and keeping it in efficient working order. The word comes from Hygeia, the classical goddess of health, whose name was derived from an older Greek word " hugies," meaning healthy. The Greeks used the term " hugieine tekhne " to mean the art of living in a healthy manner : an art which they esteemed very highly. After a long period of neglect, attention is now being increasingly paid to health, especially the health of school children. It is therefore more than ever desirable for teachers to be informed about hygiene so that they may be able to give instruction and so that they may appreciate the conditions which are desirable for the proper development of children.

It will be obvious that there cannot be a real understanding of how to maintain bodily health without some knowledge of how the body normally works : that is a knowledge of *Physiology*, the science which describes the functioning of the body. Function cannot, however, be entirely divorced from structure, so that a slight acquaintance with *Anatomy* (the science which describes how the body is made) is also necessary. Both human anatomy and physiology are only restricted aspects of *Biology* (the study of living things), and so a preliminary knowledge of general biological principles is essential to the teacher in training.

The first part of this book is therefore concerned with explaining the elements of biology, particularly their relation to the general anatomy and physiology of the human body. Having considered how the body is made and how it works, it is next shown how it is nourished and maintained, the second part dealing with nutrition and dietetics.

The next step is to apply the physiological knowledge to the maintenance of health, therefore the hygiene of children as individuals is discussed in Part III, and such matters as cleanliness, proper clothing and the use of exercise are considered. In this part, too, the important sense organs, the eye and the ear, are described. These are really organs of the nervous system, but they have such important applications in practical education that they are considered here rather than in Part I. The teeth are also described here instead of in the earlier chapter on the digestive system (to which they belong). This again is because dental hygiene has much practical importance.

From the maintenance of health we pass on to Part IV, which is concerned with children in ill-health and gives an account of the common diseases from which they may suffer. This account should be sufficient to enable the teacher to co-operate intelligently with the School Medical Service and to understand the special requirements of certain abnormal children.

In Part V we have to do with hygiene as it affects groups of children rather than individuals : the planning of school buildings, their ventilation, heating and lighting and the arrangement of special schools. The organization and activities of the School Medical Service are also explained.

Part VI deals with some more abstract aspects of hygiene, and includes a chapter on the teaching of the subject : that is the application of the knowledge derived from the earlier parts of the book.

Technical terms have been avoided as far as possible because it is much more important to know what a thing is, and what it is for, than to know its precise scientific name. Some technicalities are unavoidable, especially in the first two parts, and to assist the Reader a vocabulary is given at the end of the book.

PART I

BIOLOGICAL AND PHYSIOLOGICAL FOUNDATIONS

CHAPTER 2

THE NATURE AND CHARACTERISTICS OF LIVING CREATURES

To get some idea of the nature of living creatures, it is a good plan to consider the differences between living things and those which are without life. What is the difference, say, between an elephant and a piece of chalk. Put in that way the question appears absurd, because the differences between an elephant and a piece of chalk are so many and so manifest. If, however, we consider not an elephant but a very minute living thing, such as one of the germs of influenza, and compare that with a grain of chalk, then the differences between the living and the lifeless are not obvious, and it becomes a matter of importance to decide just what are these differences.

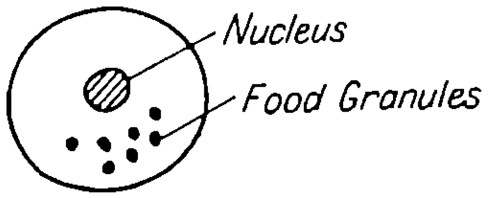
Protoplasm.—Lifeless things are made of an almost infinite variety of material. Thus you may have a piece of iron or tin, a lump of stone, a glass of water, a roomful of air and so on, all lifeless but all different. Living things, on the other hand, are all made of the same material; a clear, colourless, transparent jelly called protoplasm, a word which means "primitive jelly." It may be objected that human beings, and indeed most familiar animals, are not colourless; but this is because pigments of various sorts are mixed with the protoplasm of which they are composed.

Cells.—Protoplasm differs from all other substances in an important respect. If, for example, one takes a piece of blackboard chalk, it is nothing but a mere piece of chalk, the same in all its parts. If it be broken in half, the halves are still mere pieces of chalk exactly like the original, except in size. Even an enormous piece of chalk, such as one of the chalk cliffs at the seaside, is still no more than a mere piece of chalk, though of considerable size. In other words, lifeless things can generally exist in indiscriminate quantities, large or small. Protoplasm, on the other hand, can only exist in certain unit masses or blobs, microscopic in size, and called cells. Therefore, when Nature wants a large mass of protoplasm, such as a hippopotamus, she has to take many millions of these cells, support them upon a skeleton, or framework, and wrap a skin round the outside. In fact, a large animal such as man is made up of millions of unit cells, just as a large building is made up of thousands of bricks.

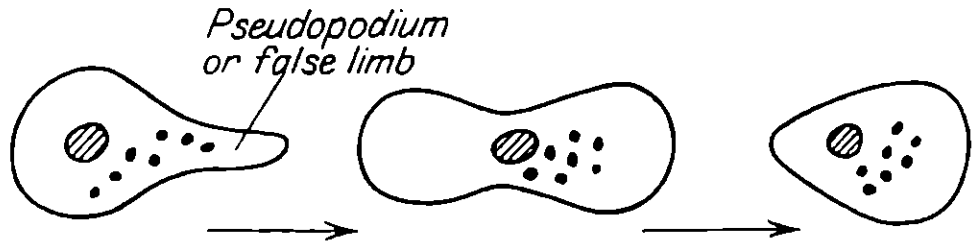
The term cell is applied to the protoplasmic unit because the earliest cells to be studied were those of plants, in which each drop of living jelly is placed in a little space or cell, surrounded by woody or fibrous material. The word was later applied to the protoplasm itself and extended to include animal as well as plant protoplasm.

Amœba.—In order to study the nature of living creatures, it is clearly desirable to start by studying the cells of which they are composed. To do this, it is not ordinarily convenient to take one cell from a human body and study it any more than we should take one brick out of a building to study that. In the case of the brick, we should go to a brickyard and begin our studies on a brick which was lying about by itself. Similarly, in the case of living cells it is best to look for a cell which is living by itself and does not form part of anyone's body. Fortunately for our purpose, a little animal exists which is made of a single cell—a single unit of life. This creature is called the amœba and is found widely in Nature wherever there is moisture, as for instance, in ponds and pools.

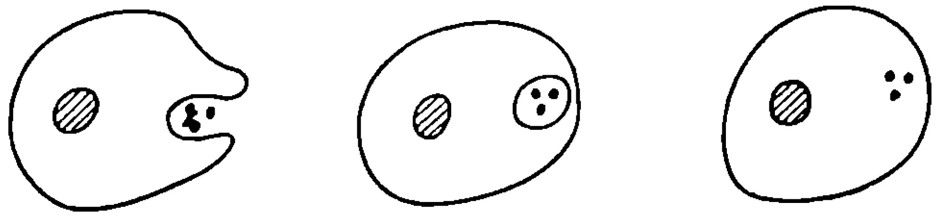
When examined under the microscope, the amœba appears somewhat as in Fig. 1 : it is simply a spherical blob of protoplasm. With suitable lighting and focussing of the microscope, certain details can be made out. First, a somewhat denser portion near the centre which is termed the *nucleus.* This structure is present in almost all living cells and is apparently the most important part of the cell. If the protoplasm is injured or partly destroyed, the cell can generally repair the damage and go on living, provided



The amœba at rest.



Three stages in the movement of the amœba.



How the amœba takes in food.

FIG. 1.—The amœba.

the nucleus is not affected. If the nucleus is injured, then the cell dies. In addition to the nucleus, the protoplasm of the amœba usually contains a number of *granules of food material.*

Amœboid Movement.—If this little creature is kept in water which is at the right temperature for its life (60° F.) and which contains sufficient food for its needs, it may be seen to move about under the microscope. The manner of its progression is shown in Fig. 1. First, a small bud or outgrowth of the protoplasm appears at one side of the cell.

The rest of the protoplasm gradually flows into this bud, carrying the nucleus and the food granules with it, until eventually the creature has moved a little bit to one side. Repetition of these events leads to further movement. The protoplasmic bud acts as a sort of limb, yet it is clearly not a real limb like one of our own arms or legs, so it is called a *pseudopodium*, from two Greek words meaning a false limb. Some of the cells in our own bodies can move about in this way, notably certain cells in the blood, which

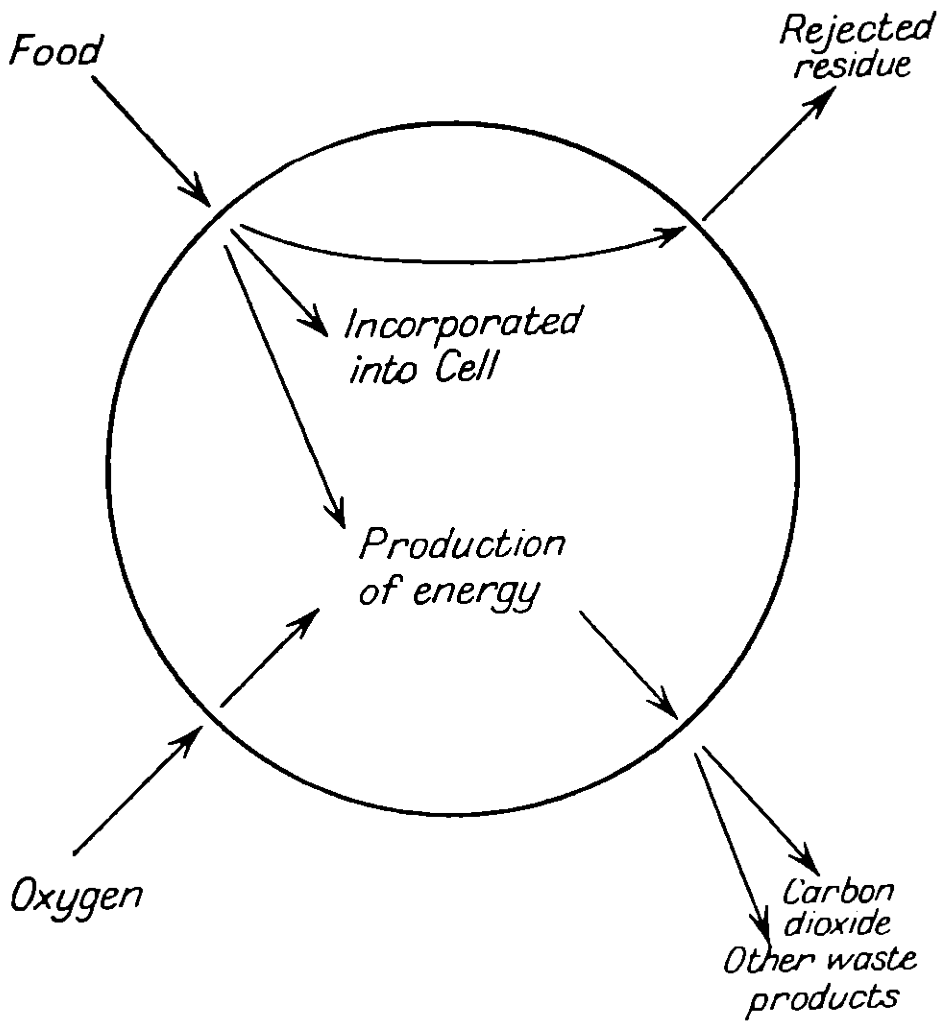


FIG. 2.—The vital activities of the amœba.

can move within the blood vessels just as the amœba does on a glass slide under the microscope. Such movement is usually called *amœboid movement*.

Cell Activities.—The amœba can also be seen to feed, as shown in Fig. 1. When a suitable granule of nourishment gets into its vicinity, it throws out two pseudopodia, surrounds the food and presently engulfs it completely into its own protoplasm.

Fig. 2 shows in diagrammatic form some of the ordinary

activities of the amœba. The water in which it lives contains food and a gas called oxygen which are continually being taken up into the cell. The arrows in the diagram perhaps suggest that food and oxygen each enter at separate, special points on the cell boundary. This is not the case, as each of them passes into the cell at any point. Human beings, too, have to be supplied with food and oxygen. We get food from various sources and take it in by way of the mouth, while we extract oxygen from the air which we have breathed in through the nose.

Within the cell, one of three things may happen to the food which has been ingested. Some of it may prove to be indigestible and not nourishing, so the amœba pushes it out again as *rejected residue.* Another part may prove to be satisfactory food so it is *turned into protoplasm*, that is, incorporated into the substance of the cell, thus allowing the creature to grow and to replace the wear and tear of everyday life. Human beings also build up their flesh from the food they have taken in and eject from the body the useless or indigestible portions of the diet. A third portion of the food, together with oxygen, undergoes complex chemical changes, which result in the *production of energy.* In the case of the amœba, this energy is seen in its movements on the microscope slide, and in the case of a human being, the energy is made manifest in the many movements of our daily life. The chemical changes which lead to the production of energy also give rise to waste products, which are got rid of from the cell. One of these waste products is sufficiently important to be put down in the diagram under its own name : this is a gas known as carbon dioxide. The amœba, therefore, takes from the surrounding water the gas oxygen and gives up to the water carbon dioxide. When human beings breathe, they take oxygen from the atmosphere and breathe out carbon dioxide. Notice that two kinds of waste matter emerge from any living creature. First, the rejected residue of the diet, and second, waste matter which has originated within the creature as a result of the chemical changes which led to the production of energy.

Characteristics of Living Matter.—Table I sets out the characteristics of living matter. *Breathing* and *feeding* have already been dealt with. *Excretion* means getting rid of waste products, the prefix "ex" being the same that is found in the word exit, a way out. These three things are peculiar to living creatures, and no lifeless thing performs these functions.

TABLE I.—THE CHARACTERISTICS OF LIVING MATTER

Breathing.	Takes in oxygen and gives out carbon dioxide.
Feeding.	Takes in material and digests it. Incorporates some into itself and ejects the remainder.
Excretion.	Gives off waste products, the result of its own activity.
Contraction.	Diminishes in size.
Conduction.	Impulses or sensations travel through protoplasm.
Irritability.	Reacts to stimulation from its surroundings.
Reproduction.	Gives rise to new life.

Contraction.—Contraction, although a characteristic of living matter, is also a characteristic of some lifeless things. It means simply the power of shrinking or getting smaller. A piece of elastic, which has been stretched, contracts when it is released. A railway line, heated by the sun on a hot day, contracts and becomes shorter during the cool night. An amœba, observed under the microscope, can be seen to shrink and become smaller in certain circumstances. Some of the cells in the human body can also contract, and the importance of this will be shown in a later chapter.

Conduction.—Conduction is not easy to describe, as not very much is known about it. Consider, first, examples of conduction in the lifeless world. A piece of wire conducts an electric current. A metal poker stuck in the fire conducts heat to a hand grasping the other end. Protoplasm conducts, not electricity or heat, but what may be called sensations. If a drop of vinegar is placed on the left of an amœba, the creature moves away from it towards the right, since it doesn't like vinegar. Notice that the drop of vinegar was on the left, but the pseudopodium which initiated the movement was on the right. It is clear,

therefore, that some sort of sensation has been conducted through the protoplasm of the living cell from left to right. Similarly, if you step with your bare foot upon an upturned drawing pin, an exclamation of pain comes from your head at the other end of the body. Clearly, then, a sensation has been conducted by the body cells from the foot to the head.

Irritability.—From the foregoing remarks, it will be seen that protoplasm, in the form of a living cell, not only conducts but performs activities in response to stimulation from the external environment. In the example given, the amœba moves away when the drop of vinegar is placed near it. This response to irritation (or other forms of stimulation) is termed irritability.

Reproduction.—Reproduction is again an essential characteristic of living matter, and no lifeless thing can reproduce its kind. The amœba reproduces in a simple manner. It grows bigger and bigger and presently divides in half: the nucleus first and then the protoplasm, so that two cells are formed, which presently separate from one another and go their own ways. Most of the cells of our bodies can reproduce in this manner, which enables injuries to be repaired and, in the case of a child, growth to take place.

Of the characteristics of living matter set out in the Table, breathing, feeding, excretion and reproduction are peculiar to living things and are not done by lifeless things. Contraction and conduction, although important characteristics of living things, are nevertheless imitated by some lifeless things.

Cell Specialization.—Such a creature as an amœba, composed of a single cell living an isolated existence, has to perform all these functions for itself. When a cell forms part of a large body, such as that of a man, it generally specializes in doing only one of these things as its principal occupation, performing the other functions only in minor degree or not at all. Thus, some cells conduct but never contract or reproduce. Others reproduce but never contract or conduct. A human being, living alone, away from

his fellows, has to hunt, kill and cook his own food, make his own clothes, build his own house, and generally do everything for himself. When men live together as members of a more or less civilized community, then although each man could perhaps do everything for himself if he had to, in practice they generally specialize, one making clothes not only for himself, but for the whole community, another building houses, and so on. When men specialize

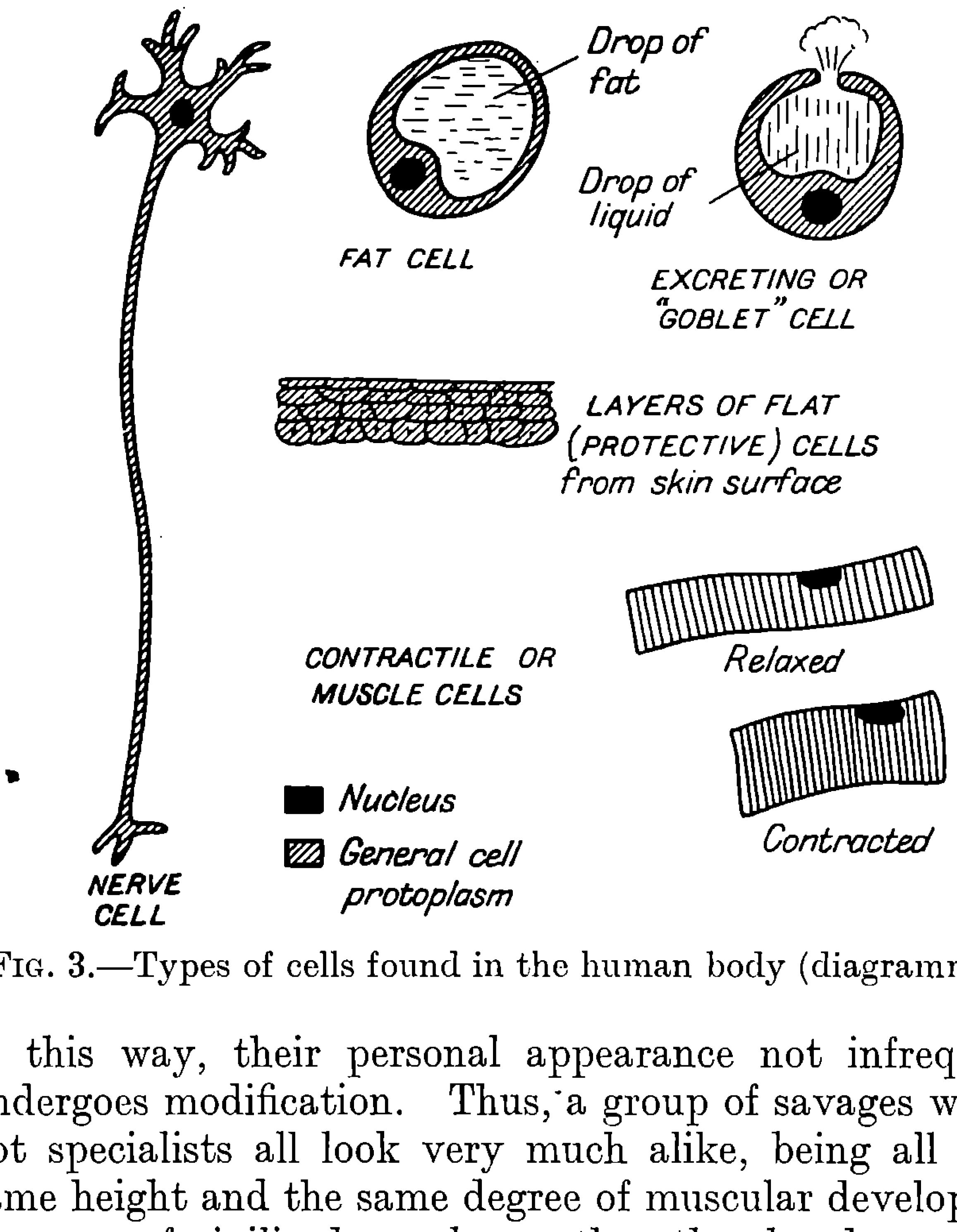


Fig. 3.—Types of cells found in the human body (diagrammatic).

in this way, their personal appearance not infrequently undergoes modification. Thus, a group of savages who are not specialists all look very much alike, being all of the same height and the same degree of muscular development. A group of civilized people, on the other hand, as seen in an ordinary city tramcar, look very different from one another. They are specialists. Thus a tall, strong man may be a policeman, while a short bow-legged man be a jockey. The same thing is seen amongst cells. When

they specialize, their appearance changes. Fig. 3 shows a number of cells such as are found in the human body. Some of them look very much like the amœba : others, at first glance, appear to bear no resemblance to the typical cell which has been described. All, however, consist essentially of a blob of protoplasm with a nucleus in the centre.

Human Cells.—The *fat cell,* shown in Fig. 3, has specialized in storing food material for the body in the form of fat. It contains a large globule of fat which has thinned out the protoplasm of the cell and pushed the nucleus away to one side. If the body as a whole is starved of food, a fat cell such as this will give up its store to nourish its fellow cells. The *excreting cell* (sometimes called a *goblet cell* on account of its appearance) specializes in getting rid of waste products. A drop of excretory liquid accumulates within the cell, and then escapes by an opening at one end. Layers of *flattened cells*, such as form the skin and afford protection to the whole body, are shown. There is also a *muscle cell,* that is a specialist in contracting. It is shown in both its contracted and relaxed condition.

Tissues, Organs and Systems.—A number of cells collected together, all looking alike, and all performing the same work, are collectively known as a *tissue.* Several tissues together make an organ. Thus, the tongue is the organ of taste ; it contains muscular tissue, that is to say, contracting cells which enable the tongue to make the movements necessary for speech. It is covered by a protective tissue of cells and in certain parts there are specialized tasting cells—a tasting tissue. Several organs may work together to form what is known as a *system.* The tongue tastes the food, the teeth grind up the food, the stomach and bowels digest the food, and all these organs together form the digestive system. Finally, a number of systems such as the digestive system, the breathing system, the circulatory system and so on, form the complete animal or human being. These groupings of cells within the body may be likened to the arrangement of

such an institution as the post office. There the individual employees correspond to the individual cells of the body. Certain of them, all wearing the same uniform and performing the same task of delivering letters, constitute a department, and correspond to a collection of cells forming a tissue. The post office in any one town contains a number of departments, the sorting department, the telegraph department, etc., these departments forming one post office, just as several tissues form one organ. Moreover, the post offices of the various towns in the country together form the postal system, just as a number of organs may be linked together to form a system in the body. Finally, a complete, civilized community is made up of many systems or public services, such as the postal service, transport services and the like, and so a complete body is made up of a number of physiological systems.

In the following chapters the various systems of the human body are described in turn.

CHAPTER 3

THE SKELETON

In the last chapter it was shown that the bodies of human beings and of animals are composed of countless millions of cells. Each of these cells is a minute blob of the living jelly called protoplasm. The flesh is therefore soft and yielding, so before Nature could make a creature with more rigidity than a slug or an earthworm, she had to devise some means of supporting the soft flesh.

The necessary foundation for the human body is supplied by the bones, which collectively are called the *skeleton* (Fig. 4). If firm support were the only consideration the skeleton might well take the form of a number of large, massive bones, but such an arrangement would not be much use for an animal like man, who is intended to perform many complicated movements with his limbs and trunk during his daily life. In order to combine strength with flexibility, Nature has adopted the device of making the skeleton of a relatively large number of small bones (over two hundred in all). These are jointed together, so that a good deal of movement is possible.

Vertebral Column.—The best starting point for the study of the skeleton is the so-called *backbone*. On referring to Fig. 5 it will be seen that this term is a misnomer, since there is not one backbone but twenty-four separate bones piled one on top of another to form a sort of column, the *vertebral column* or *spine*. The possession of a vertebral column is characteristic of all the higher, freely moving animals from the elephant down to the frog, and all animals which have this formation are called *vertebrates*. The human animal therefore belongs to this group.

A single vertebral bone or *vertebra* is shown in Fig. 6. It consists of a solid portion, the body, together with branching pieces of bone forming a sort of archway, the

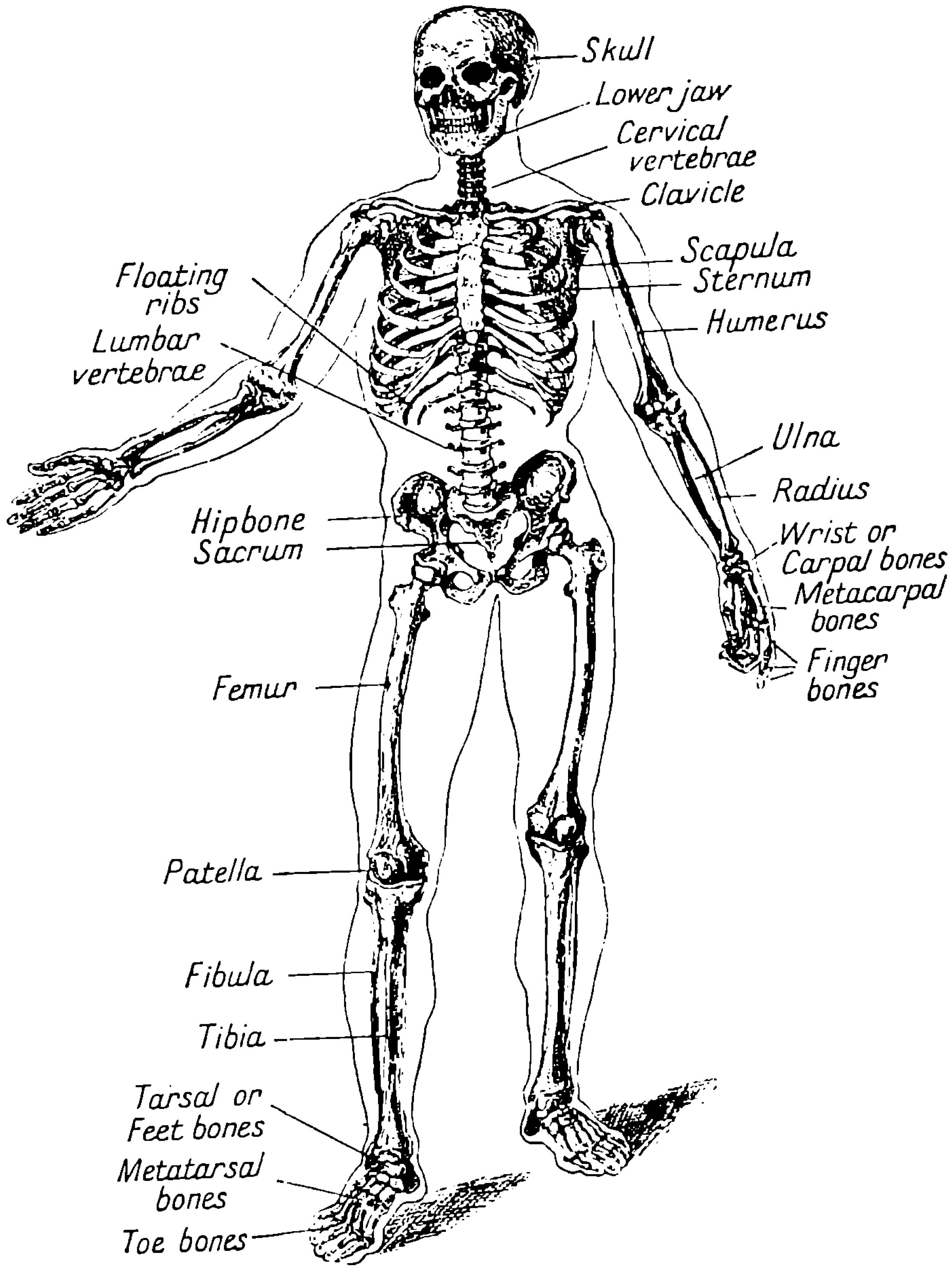


FIG. 4.—The skeleton.

whole arrangement being not unlike a signet ring. When these bones are arranged one on top of the other in a living person, the bony archways form a tunnel down the vertebral

column. In this tunnel lies the spinal cord, a very important portion of the body, which is thus protected from injury (see Chapter 9). From the arch of the vertebra a number of bony spikes project. To these are attached strong, fibrous bands or *ligaments* (Fig. 7) which serve to hold the bones firmly in place one against the other.

The bodies of the vertebræ are not in actual contact with one another during life, but are separated by discs of cartilage or gristle called *intervertebral discs* (Fig. 7). The arrangement is something like the layers of mortar between successive stones in a pillar. These discs of cartilage are somewhat soft and elastic and consequently they act as dampers to the jars and shocks which otherwise would shake the whole vertebral column every time its owner brought his foot down upon the ground.

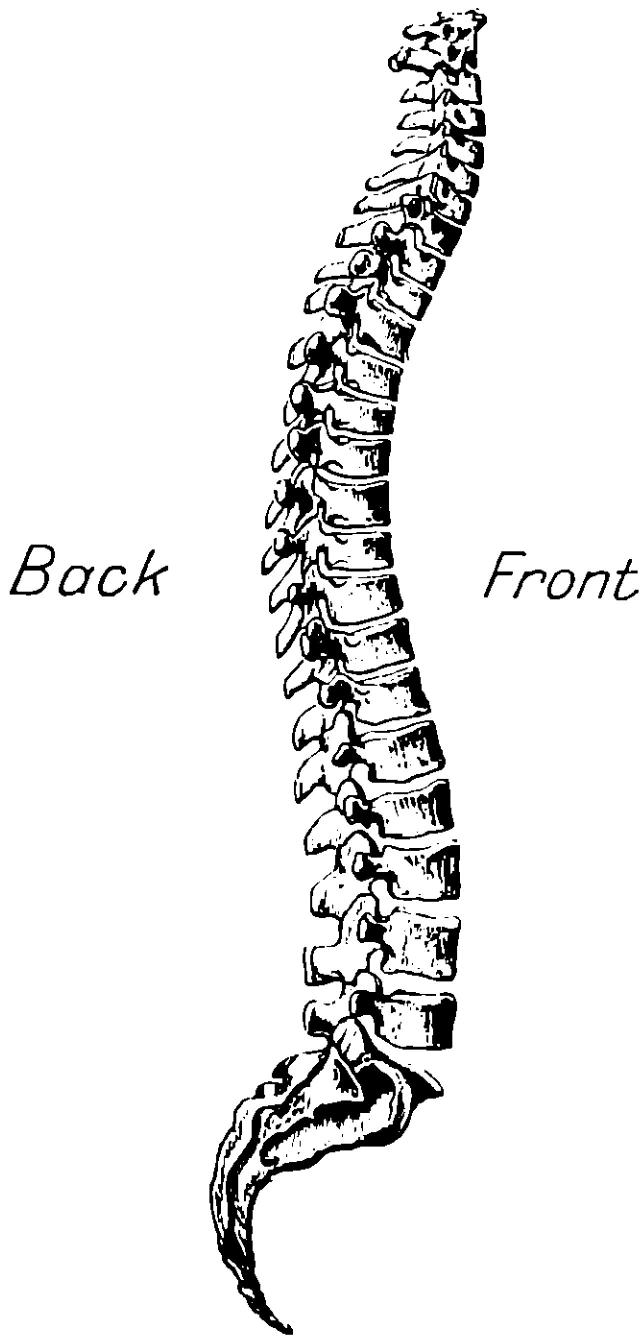


FIG. 5.—The vetebral column.

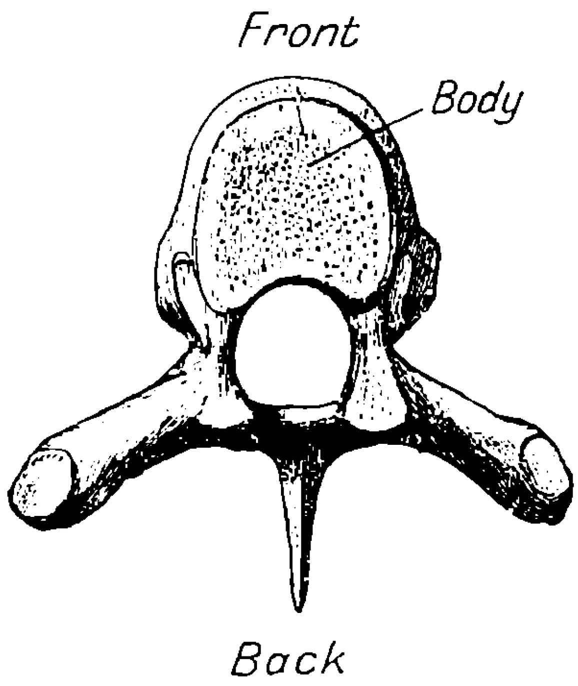


FIG. 6.—A vertebra seen from above.

Spinal Curves.—Fig. 5 shows the twenty-four vertebral bones, together with a large bone, the *sacrum*, which forms

the base of the vertebral column. Looking at the column as a whole, it is clearly not upright, but is distinctly curved, an arrangement which adds to its flexibility and springiness. In the region of the shoulders there is a curve with its

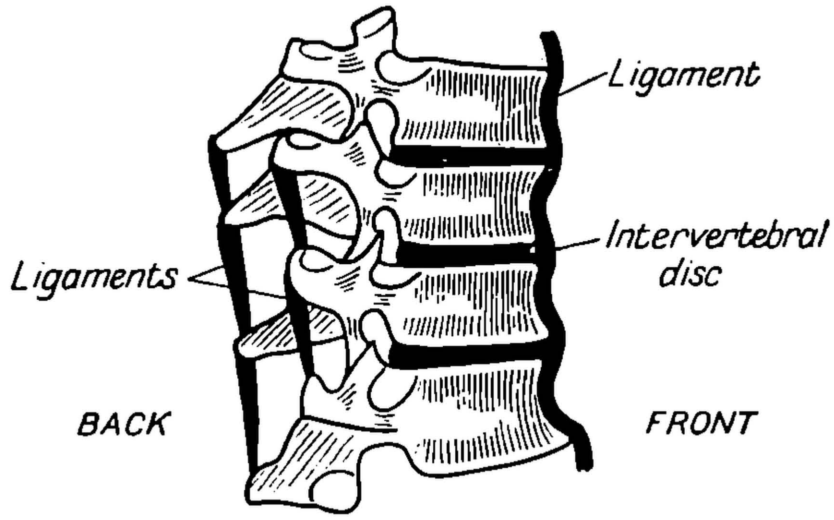


FIG. 7.—Part of the vertebral column showing ligaments and cartilages (semi-diagrammatic).

convexity to the back, and below this, forming the small of the back, is another curve with its convexity forward. The sacrum at the bottom of the vertebral column is again curved with the convexity behind, while in the neck region

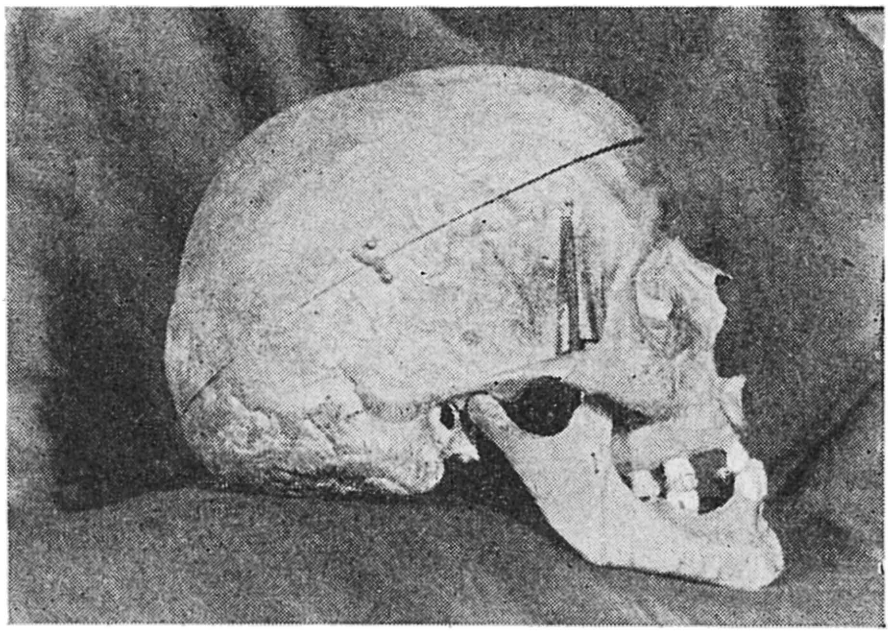


FIG. 8.—The skull seen from the right side.

is a slighter, less distinct curve with the convexity forward. In certain diseases of the spine the arrangement of these curves is altered, as will be seen later.

The Skull.—On top of the vertebral column the skull is poised. This mass of bones consists of two parts : the

face in front and the brain-box or *cranium* behind (Fig. 8). In the face (Fig. 9) are a number of openings for the important sense organs, the eyes, the nose and the tongue, while at the sides of the face are similar openings for the organs of hearing (Fig. 8). In these openings the sense organs lie recessed and consequently well protected from damage from outside. Above and behind the face is the cranium, a hollow part of the skull which contains the *brain*. The brain is naturally a very important organ of the body, so Nature endeavours to protect it by placing it in this strong, bony box. If the skull was made of very thick, strong bones the brain would undoubtedly be well protected, but such a weight of bone would tax a man's strength to hold it on top of his vertebral column throughout the day. For this reason the skull is dome shaped, which enables much thinner bone to be used while still retaining a good deal of strength. The arch is well known to be a strong type of curve and a dome is simply a collection of arches arranged in many planes. Nature follows a similar plan in the case of birds' eggs, where strength, together with reasonable lightness, is required. Seen in section (Fig. 10), the *cranial bones* are not solid, but consist of an outer plate of bone and an inner plate joined together by a network of bony strands. This device also combines lightness with rigidity, and is comparable to the lattice arrangement used by engineers in building bridges, electricity pylons and the like.

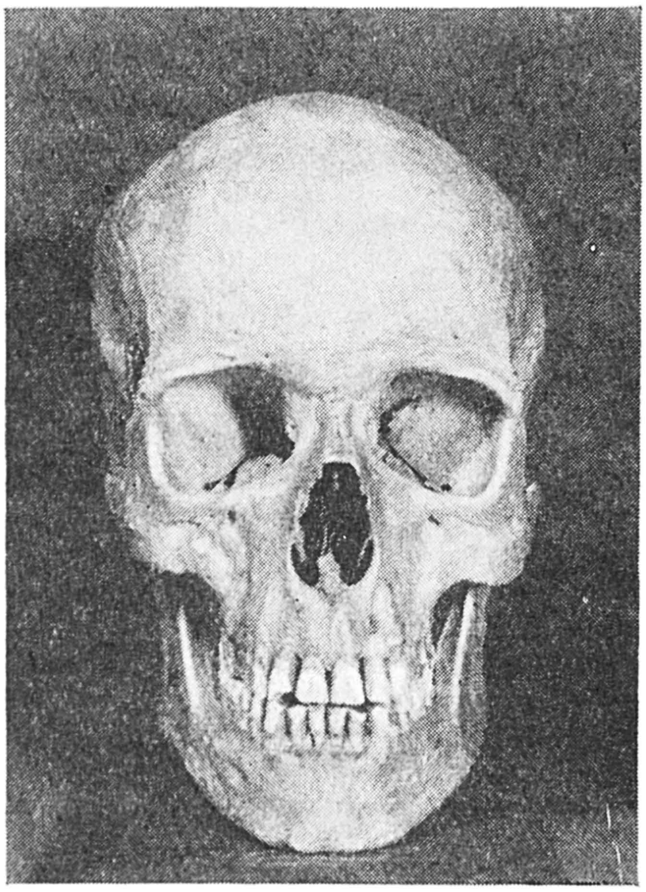


FIG. 9.—The skull seen from in front.

It has been said that the skull is poised upon the upper end of the vertebral column and in this position it can be

freely turned from side to side, which is important for man in that it allows him to turn his eyes, ears and nose in various directions, and so become aware of objects in his environment without having to approach closely to them.

The Chest.—Other organs of the body quite as important as the brain are the *heart* and *lungs*. These are protected by the *ribs*, attached to the vertebral column behind and to the breastbone in front, as can be seen in

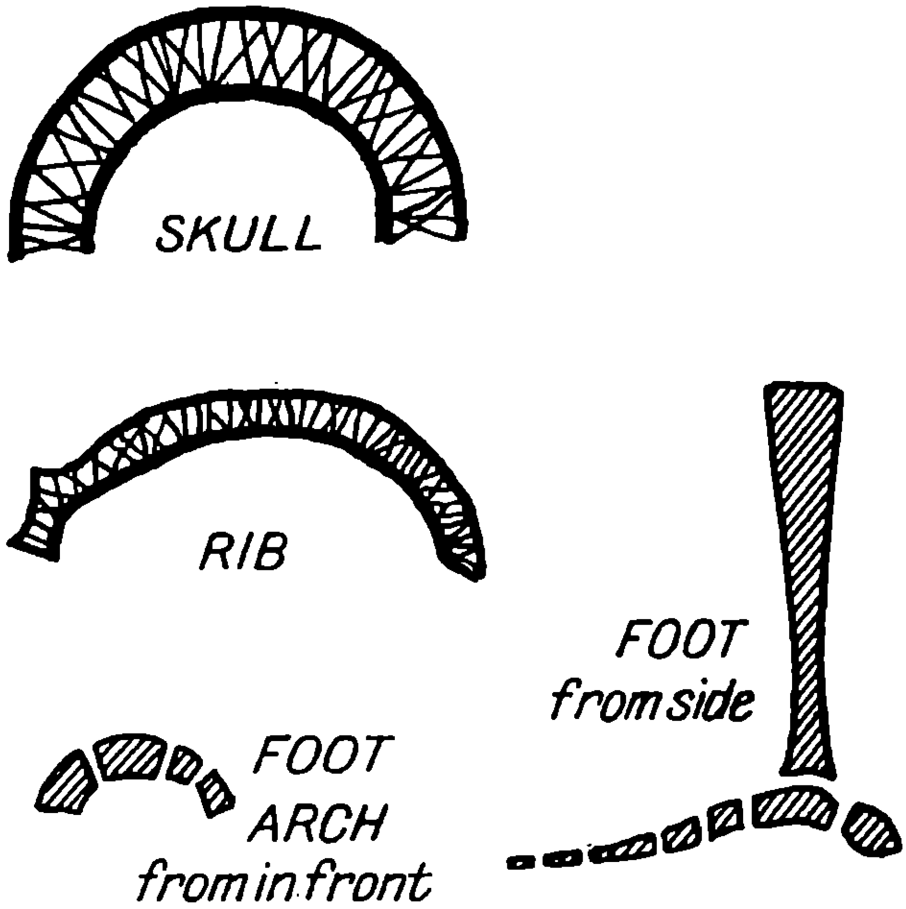


Fig. 10.—Use of the arch in the human body.

Fig. 11. Although the organs in the chest require protection, it is not practicable to make a solid, bony box in this instance because of the necessity for the movements of breathing. Consequently, Nature has made the skeleton of the chest in the form of a cage rather than a box. Each rib is bow shaped (Fig. 10), Nature again making use of the arch to combine lightness with strength and, on section, the interior of a rib shows the same lattice-like arrangement of bone as was seen in the skull. The bow shape of the ribs also makes them springy and so they break the force of blows which may be applied to the chest.

The Limbs.—Leaving the trunk, we can now consider the skeleton of the limbs. Fig. 12 shows a primitive pattern on which both upper and lower limb designs are based. The section nearest to the trunk (upper arm, thigh) contains a single bone. The next section (forearm, lower leg) contains two bones side by side. The next section (wrist, ankle) contains a number of small bones arranged in two rows, while the last section (hand, foot)

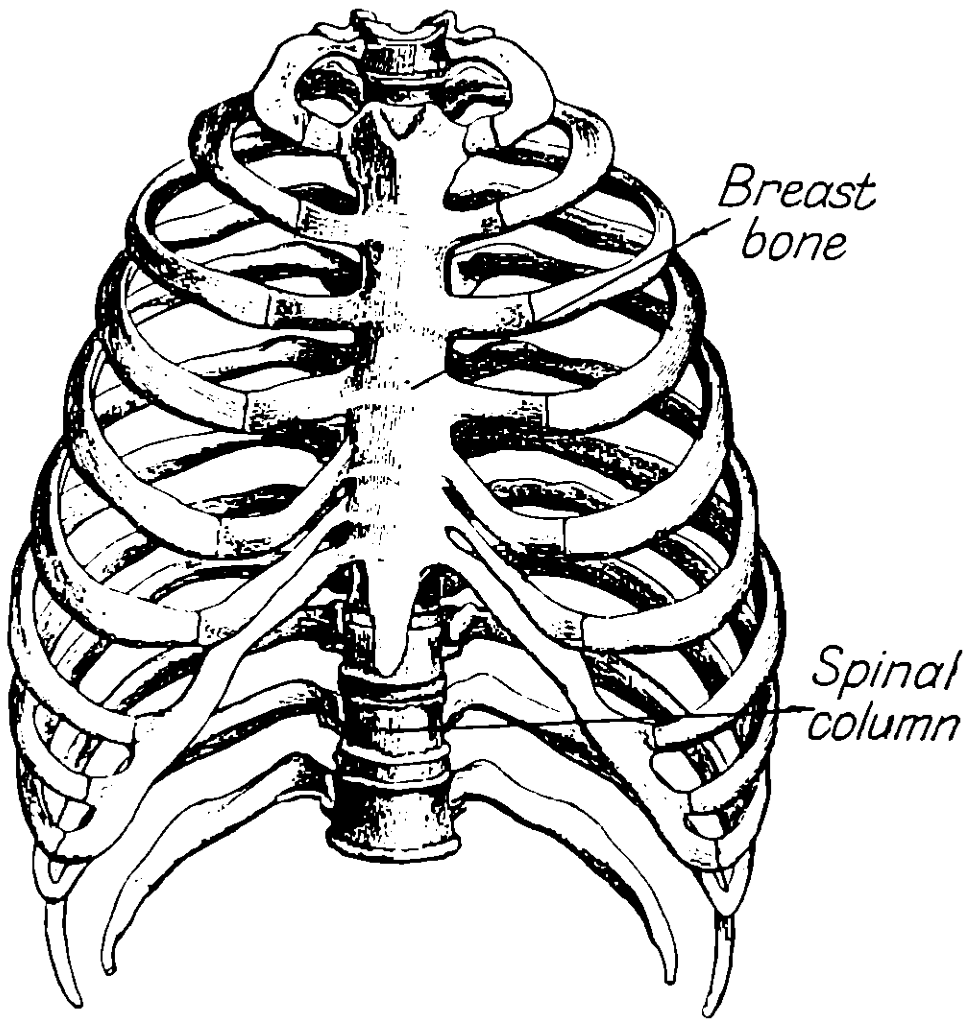


FIG. 11.—The Framework of the chest.

contains five, more or less parallel, rows of oblong bones. This primitive limb pattern is modified in different animals to serve various purposes. In such an animal as the horse support of a heavy body is the primary consideration: so the bones of both limbs have become strong and massive, but are somewhat limited as regards their range of movement. A horse has evolved four legs, and is able to walk and run but not to grasp or handle objects. In an animal such as a monkey, free movement and flexibility have been the prime objects. In this case the bones of each limb

have become light and very freely jointed to give a wide range of movement, but have not much value for supporting the body weight. A monkey has evolved four arms. Human beings have done better than other creatures in evolving a pair of arms and a pair of legs, so that man can not only walk and run like the four-legged animals, but can climb and handle tools and utensils. To this last ability he owes, in large measure, his superiority over the other animals. Two movements in particular illustrate the

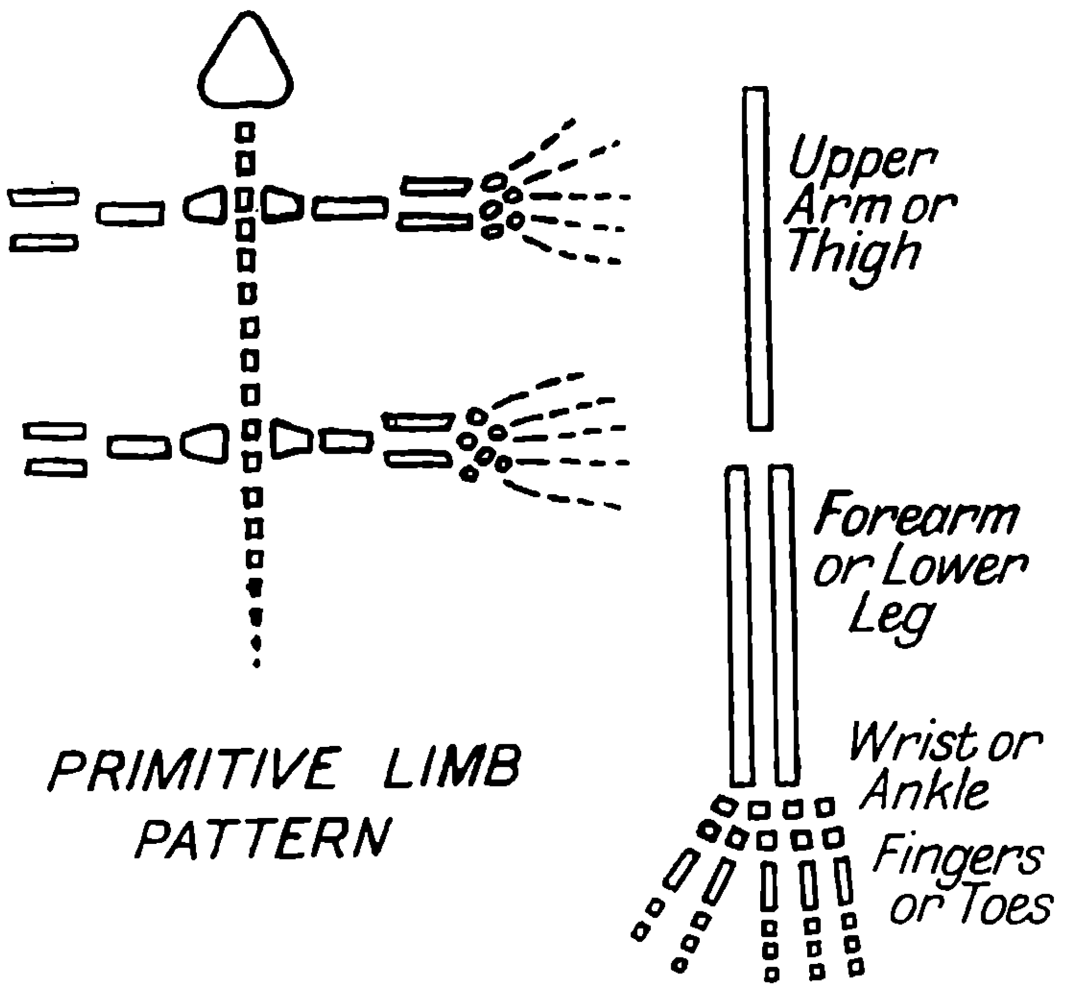


FIG. 12.—Primitive limb pattern.

difference between the human upper and lower limbs, although both are built upon a common plan. In the upper limb the forearm can be freely rotated, making the palm of the hand turn either upwards or downwards; while the thumb can be moved freely and placed with its tip in contact with any of the four fingers. No such movements are possible in the case of the lower limb, nor is movement so desirable here, since the business of the lower limb is to afford rigidity and support to the weight of the body. The power to perform these movements with the

upper limb, however, has enabled the human race to grasp and use tools and so to build up a complex civilization. A moment's thought will bring to mind a host of operations in daily life which necessitate the use of these movements.

The Foot.—The bones of the foot, as can be seen in Fig. 10, are arranged in an arch-like formation to add to their strength and to give springiness to the gait. When looked at from the side, a distinct arch is seen extending from the ball of the big toe to the heel and, when looked at from in front, an arch is seen extending from one side of

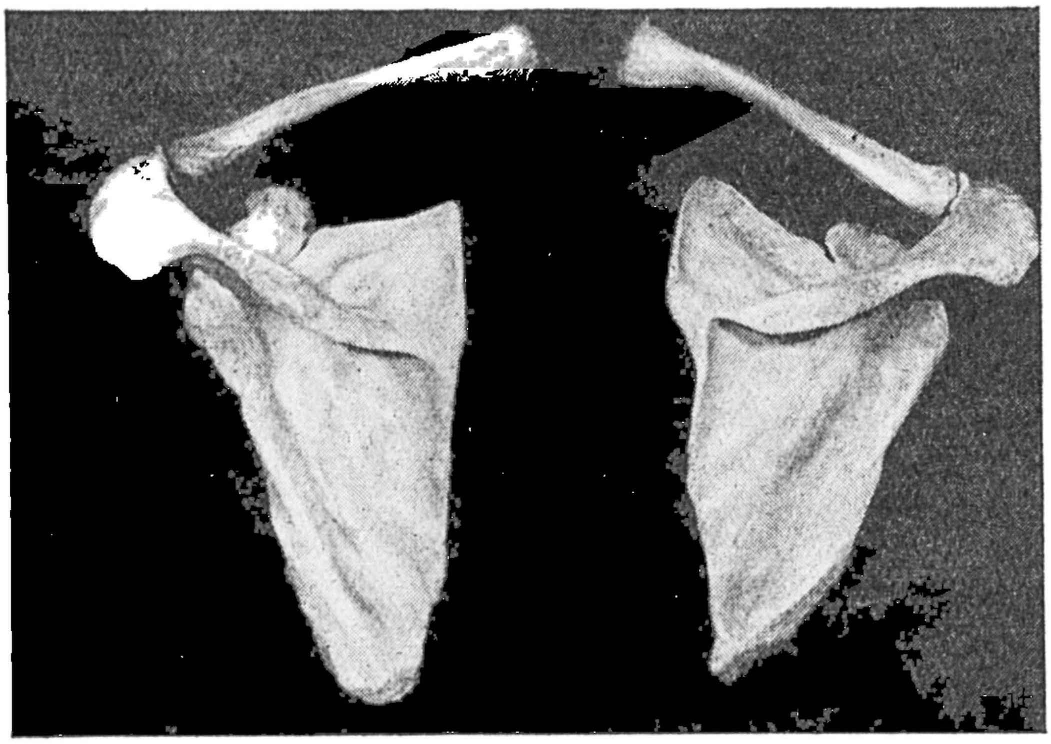


FIG. 13.—The shoulder girdle (from behind).

the foot to the other. The bones are bound together and supported by fibrous strands. In certain circumstances, these strands become weakened and stretch, allowing the arches of the foot to collapse. The resulting condition is termed flat foot and it is characterized by a loss of springiness and lightness in the gait. More will be said of this in a later chapter.

Shoulder Girdle.—The skeleton of the upper limb is attached to the trunk by several intermediate, connecting bones which form a rough and somewhat imperfect ring encircling the body at the level of the shoulders: this ring of bones is termed the *shoulder girdle* (Fig. 13). It consists

of the two *shoulder blades* behind, and the two *collar bones* in front. The collar bones join the breast bone just as do the ribs, but the shoulder blades are not attached to the vertebral column behind. They merely lie flat and loose on the ribs, being bound down by layers of muscle and the skin on top of them. The single bone of the upper arm is attached to the shoulder blade at the shoulder joint. The bones of the shoulder girdle, like those of the arm, are somewhat slender and freely movable, thereby assisting the arm to make its wide range of free movement.

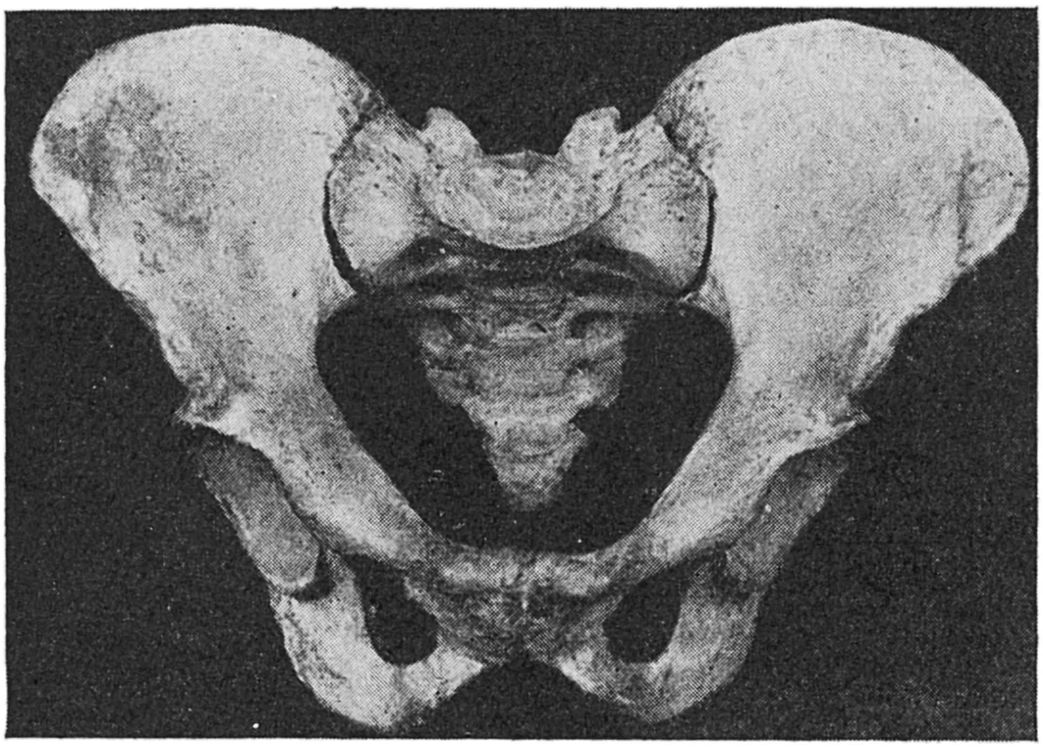


FIG. 14.—The hip girdle or pelvis (from in front).

Hip Girdle.—The skeleton of the lower limb is also attached to the trunk by a ring of bones termed the hip girdle (Fig. 14). In this case the ring is complete, being formed of the two hip bones in front and at the sides, and a triangular bone, the sacrum, at the base of the spine behind. These bones are strong and massive, not at all movable upon one another, but well adapted to give firm support to the body weight. The hip girdle once more illustrates Nature's use of the arch as a means of attaining great strength. The two hip bones curve round towards the back of the body and the sacrum fits in between, forming the keystone of the arch. The wedge shape of the sacrum is apparent in Fig. 14. The term *pelvis* (Latin : a

basin) is often used for the hip girdle on account of its shape, like a basin with the bottom knocked out.

Joints. ***General structure.***—In addition to supporting the body, the bones form a system of levers which are able to move upon one another by virtue of the joints which occur in those places where two or more bones come into contact with each other. Fig. 15 shows, in simplified form, a section through such a joint as the knee. For the sake of clarity rather more space appears within the joint than is actually the case in life. The ends of the two bones forming the joint are subject to a good deal of friction and pressure as movements are made. To prevent damage or

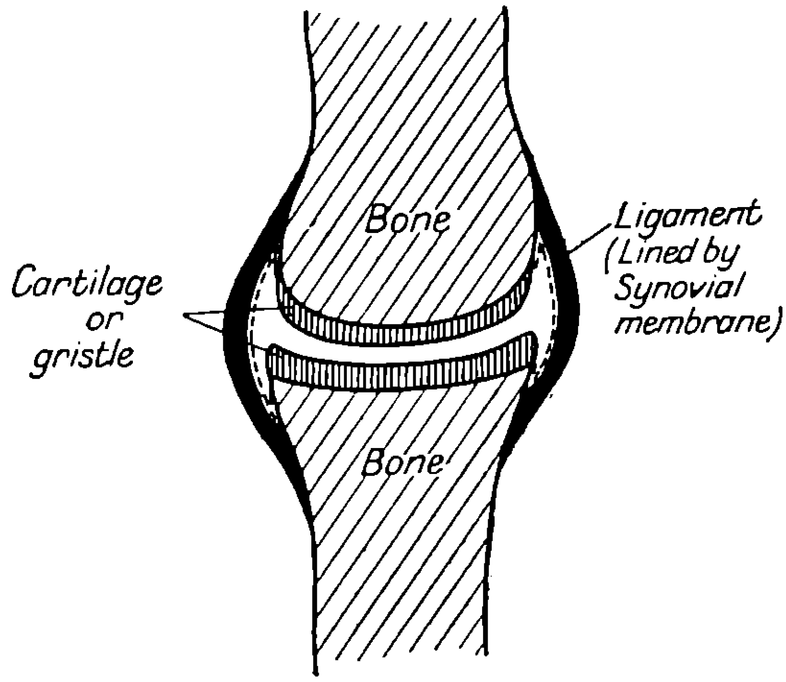


FIG. 15.—A section through a joint.

wearing away of the bone, the surfaces of contact are covered by cartilage or gristle, somewhat harder than that forming the intervertebral discs. This cartilaginous covering is readily replaced throughout life as wear and tear take place. The bones are kept in contact with one another by strong, fibrous bands (known as *ligaments*) which run from one bone to the other across the joint. These are indicated at each side of the figure, but in an ordinary photograph would be seen to surround the joint entirely, forming a tough, leathery cover which is called the *joint capsule.* The interior of this capsule is covered by a thin skin or membrane, the *synovial membrane*, the cells of which secrete a liquid, the *synovial fluid.* This is a somewhat slimy, slippery

liquid which lubricates the interior of the joint and so diminishes friction.

Movement and its limitation.—Any given joint has only a limited range of movement. Thus the fingers can be curled up in the palm of the hand or straightened, but cannot be bent round to touch the back of the hand. Similarly, the knee can be bent so that the foot approaches the back of the thigh, but cannot be bent to raise the foot in a forward direction. Limitation of movement depends largely upon the arrangement of the ligaments forming the capsule of the joint. Fig. 16 shows how the ligaments at

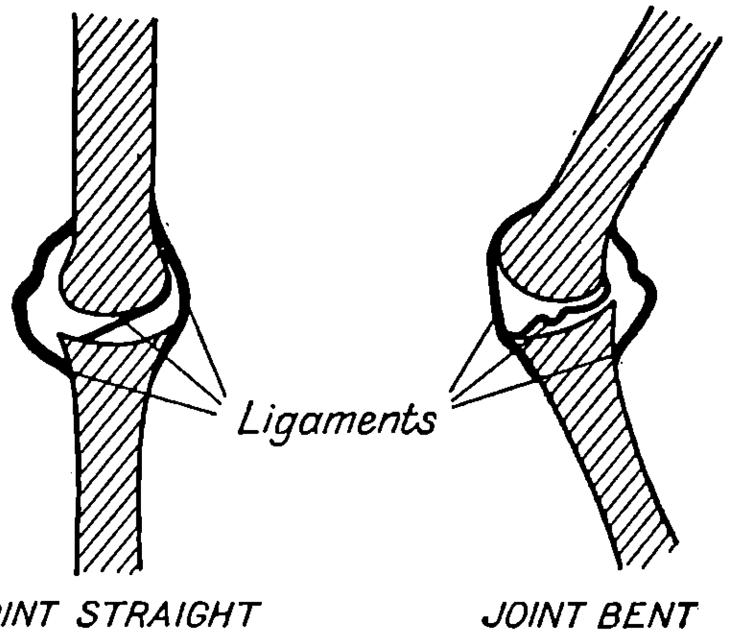


FIG. 16.—Limitation of joint movement.

one side of the joint are slack when the bones are in a straight line, and how they become tight when the joint is bent to its limit. The ligaments on the opposite side of the joint tighten and slacken in the reverse order. In some of the joints (the knee, for example) there are ligaments running across the interior which play a part in limitation of movement. Such an internal ligament is indicated in Fig. 16. The fact that joint movement is subject to limitation in this way increases the stability of the body, as the ligaments are arranged in such a manner that the weight of the body keeps the leg and trunk joints in the proper position for supporting the body weight. In Fig. 16 the space within the joint is again exaggerated for the sake of clearness.

Types of joints.—The joints of the body are usually classified according to the type of movement which each can make. The knee, the elbow and the finger joints are called *hinge joints* because the movement which they make is to and fro like an ordinary hinge. The shoulder, and to some extent the hip, are capable of a much wider range of movement. In each case one bone (upper arm, thigh) ends in a rounded, knob-like head : the other bone (shoulder blade, hip bone) receives this knob in a depression or socket. Joints of this type are called *ball and socket joints.* In some places bones come into contact without being capable of movement upon one another. These regions are also called joints, but are much simpler in structure than the ordinary, movable joints. Examples of this arrangement are seen in

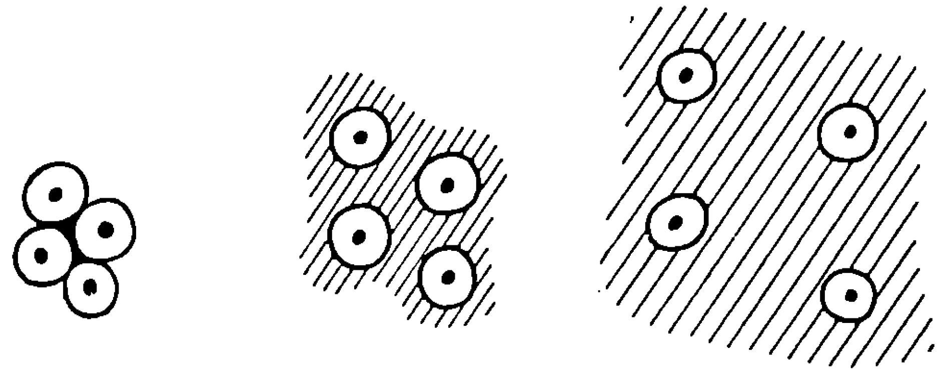


FIG. 17.—The formation of bone.

the skull, which is made of a number of separate bones firmly fixed together.

Nature of Bone.—It may occur to the reader to wonder if bone is to be regarded as living material, as it is obviously not soft and jelly-like as protoplasm has been described. The answer is that although bone is not entirely made of living cells it is made by the activities of living cells. Before birth the bones are represented by soft, fleshy masses of cells. These bone cells, as they may be called, surround themselves by lime (calcium) derived from the blood. This limey material, or bone, increases in amount until the cells are separated from one another and embedded in a mass of bone which they themselves have manufactured. This is shown in Fig. 17. The cells continue living in spaces in the bone. In later life, if the bone is broken those cells

which are near the injury manufacture fresh bone to make good the damage.

Nature of Cartilage.—Cartilage is softer than bone, but is made in much the same way, living cells producing the gristly material by which they become surrounded. Fig. 17 might represent the development of cartilage equally well as the development of bone. In many cases cartilage is formed first and then becomes impregnated with lime, and so converted into bone. This process is not complete at birth but continues during childhood, and the skeleton is not entirely calcified until adult life is reached.

CHAPTER 4

THE MUSCLES

We have seen that the skeleton is a system of levers capable, by virtue of the joints, of moving upon one another. Like levers in machinery, the skeletal levers require engines to make them move, the engines in this case being the *muscles*. A muscle is a fleshy mass consisting of cells which are specialists in contracting. Fig. 3 shows the appearance of muscle cells in both the contracted and the relaxed condition. As contraction means shortening in length, it is obvious that when millions of muscle cells all contract at the same time in the same part of the body, a considerable movement results.

Voluntary Muscle.—Muscles are generally divided into three categories. Those which affect the skeleton, causing such movements as nodding the head, raising the arm, or bending the knee, are termed *voluntary muscles*, because they are under the voluntary control of the will, and contract whenever their owner requires them to do so.

Involuntary Muscle.—Many of the internal organs (stomach, bowels) perform movements which are, of course, brought about by muscles contained in them. These muscles are not under the control of the will, indeed you are not usually conscious of their movements at all, and so they are termed *involuntary muscles*. Involuntary muscles generally contract whenever they are stretched. Thus, when food enters the stomach, this organ is distended, so the muscles of which it is largely composed contract, moving the food about in a manner which is necessary to digest it (see Chapter 7).

Heart Muscle.—The heart moves, the movement being called beating, and this movement, too, is brought about by muscle, known as *cardiac* or *heart muscle.* Heart muscle is clearly not under the control of the will and, therefore, it may be regarded as a kind of involuntary muscle, but it is more usual to classify it under a separate heading. It differs from the other two kinds of muscle in an important respect. It contracts neither at will nor only when stretched, but rhythmically, contracting and relaxing throughout life.

Parts of Muscle.—Muscles form the great bulk of the body, particularly of the limbs, and the ordinary pieces of

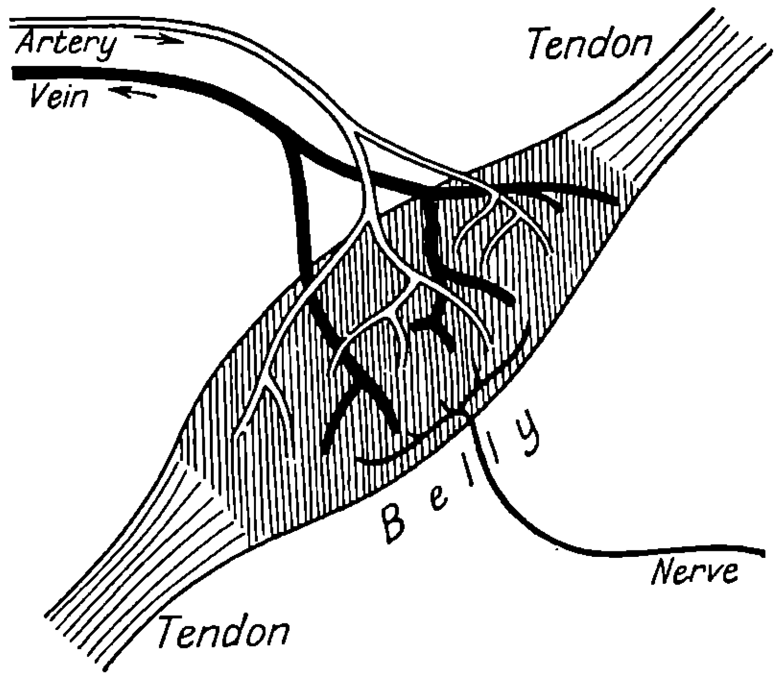


FIG. 18.—A voluntary muscle.

butcher's meat that we eat are mainly the muscles of animals. An individual muscle may be said to consist of three parts, as shown in Fig. 18. The main mass of the muscle, termed the *belly*, consists of contractile cells, but at each end these give place to tough, fibrous cells which do not contract, but which serve to attach the muscle firmly to the skeleton. These fibrous ends of the muscle are termed the *tendons*, and are somewhat similar to ligaments in structure.

Contraction and Movement.—Fig. 19 shows how the contraction of a muscle can produce movement. The

biceps, that well-known muscle of the upper arm, is attached by its upper tendon to the shoulder blade just near the shoulder joint. Its belly lies along the front of the arm bone (humerus) but is not attached to it, although held in position by the skin surrounding the arm. Its lower tendon is attached to one of the forearm bones (the radius). The dotted outline in the figure shows the position of the muscle and the bones after the biceps has contracted. The shortening of the muscle causes it to pull upon its tendons, but the upper tendons (there are two of them), being firmly attached to the shoulder blade, cannot

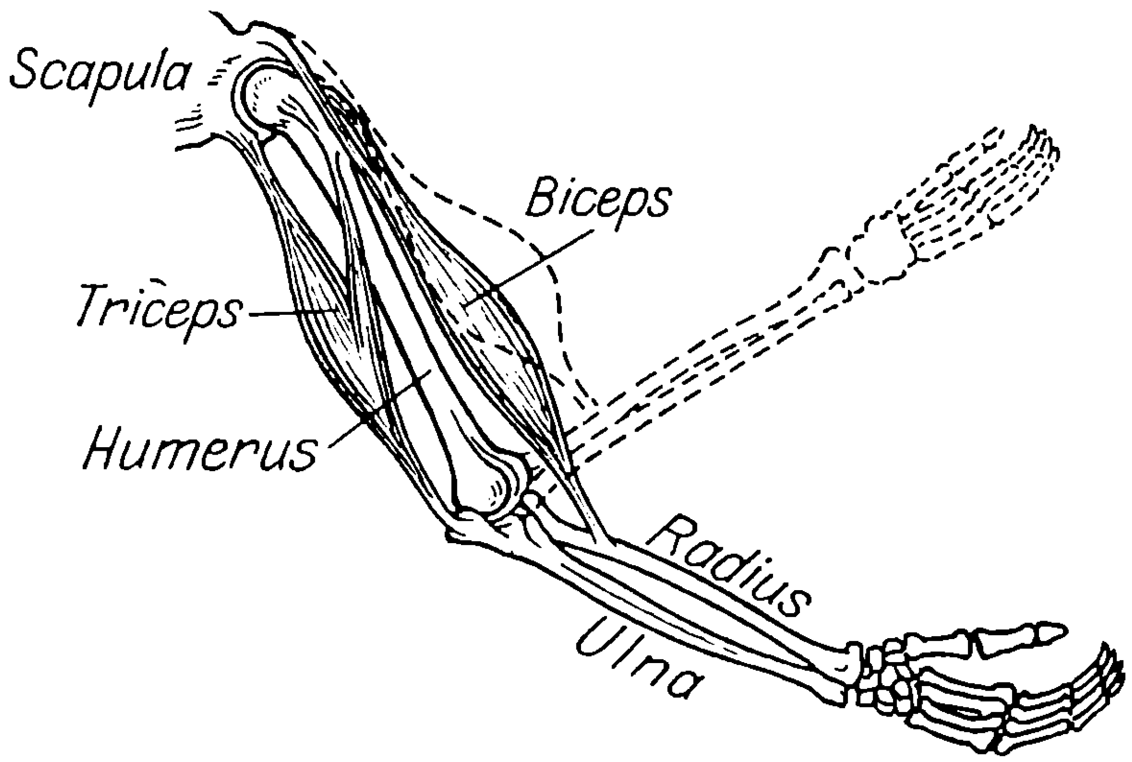


FIG. 19.—The action of the arm muscles.

move. Only the lower tendon is really free to move, and this pulls the forearm into a bent position. When the muscle relaxes, the arm straightens once more. While standing up or walking about the force of gravity is sufficient to straighten the arm when the muscle relaxes, but when lying down the arm may be in such a position that gravity does not operate to straighten it, so that another muscle, the triceps, is provided on the back of the arm to produce this straightening movement. Since the biceps and triceps act in opposition to one another, they are termed *antagonistic muscles*, and such an arrangement of muscular antagonists is usual at all joints throughout the body.

Notice further in the figure that the muscle, when contracted, is represented as being fatter than when relaxed. This is because the muscle is made up of a fixed quantity of flesh (that is, living cells), and when it becomes shorter, it must become fatter in order to accommodate the same bulk of flesh. This fattening of the biceps (or of the calf muscles) when it contracts is familiar to everybody.

Uses of Muscles.—Muscles have three uses in the body, the first being to *produce movement* in the way that has been described. The second use of muscle is to *maintain posture.* When a movement has been made, as, for example, bending the arm, it is necessary for some muscles to remain contracted, otherwise the arm would straighten itself out again. All the time we are sitting, standing or otherwise defying the force of gravity, some muscles in our bodies have to be contracted to maintain the posture. The third use of muscle is to afford *support* to those parts of the body where the skeleton is deficient, notably in the region of the abdomen. The chest is supported by the bony framework of the ribs, but below the chest the rest of the trunk has not got this skeletal support. Sheets of muscle run from the lower margin of the ribs to the upper edge of the pelvis or hip girdle. As long as these muscles remain contracted, the abdomen is held in its proper shape, and the internal organs are kept in their correct positions. If these muscles become flabby and incapable of doing their work properly, then the abdomen sags forward and the trunk lacks support. The abdominal muscles form a sort of natural corset which, when properly developed, should obviate the necessity for extraneous support.

Arrangement of Muscles.—Fig. 20 shows the general arrangement of the body muscles as they would appear if the skin were removed. The muscles already referred to can be seen, together with many others. Notice, in the forearm, the bellies of those muscles which work the fingers. If these bellies were actually in the hands, the hands would be too podgy and clumsy to do fine work. So the bellies of the muscles are confined to the forearm and long tendons

FIG. 20.—The muscles of the body.

run down to the fingers themselves. If you move your fingers as in playing the piano, and look at the back of the hand or the front of the wrists, the play of these tendons becomes apparent beneath the skin.

Connections of Muscles.—Fig. 18 shows a muscle such as the biceps, and illustrates that each muscle has three important structures connected with it. First an *artery* bringing a supply of pure blood to nourish the muscle. Such an artery divides into smaller and smaller branches until ultimately each individual muscle cell has its blood supply. The waste products which originate from the activity of the cells are carried away by the blood stream in another vessel, a *vein*. The arrangement may be likened to a house which has a supply of pure water brought to it in pipes and its impure water, or sewage, carried away in another set of pipes. A muscle is also connected to the brain by means of a *nerve* which acts as a sort of telegraph wire along which the brain sends messages, telling the muscle when to contract.

Muscular Contraction.—In order to understand the nature of muscular contraction, it is useful to use the analogy of the working of an engine, and the comparison

TABLE II.—Muscle as an Engine

	Engine.	*Muscle.*
Fuel.	Coal.	Glycogen.
Oxygen.	From air.	From blood.
Combustion.	Burning.	Oxidation.
Liberation of energy.	Movement and heat.	Movement and heat.
Waste products.	Ash and carbon dioxide.	Lactic acid and carbon dioxide.
Removal of waste.	Mechanically.	By the blood.
Accumulation of waste.	Fire is "damped out."	Fatigue.

between muscle and engine is summarised in Table II. Although such a comparison has undoubted uses, it also

has dangers, and should not be pushed too far. In order to work, an engine must be supplied with fuel, and in the case of a steam engine, this is usually coal. The human engine, the muscle, must also be supplied with fuel (or food) which, in this case, is a material known as *glycogen.* Glycogen is chemically related to starch, and is formed in the body from the ordinary food of the diet. The engine must also be supplied with oxygen, which it gets from the atmosphere. The muscle, too, needs *oxygen,* and gets it from the blood. The fuel and oxygen together undergo a process known as combustion, which, in the case of the engine, we term burning. Such combustion or burning takes place in the muscle, only there is, of course, no actual flame, so that it is more usual to speak of the *oxidation,* rather than the burning, of glycogen. Combustion results in the liberation of energy, generally of two types. Thus the steam engine moves and does work and, at the same time, it gets hot. The muscle, too, performs work, giving rise to movement, and it is common experience that during muscular exercise, the body grows hot. Combustion also gives rise to certain waste products. In the steam engine there is the ash left from the burning of the fuel and a gas, carbon dioxide. In the muscle, the oxidation of glycogen gives rise to a *waste product,* lactic acid, and to the same gas, carbon dioxide. The waste products of combustion have to be removed from the engine, the ash being raked away from the fire grate, while the carbon dioxide escapes with the smoke up the chimney. In the case of the muscle, the waste products are carried away by the blood stream as has already been indicated. If waste products are not removed from an engine, the fire presently goes out, smothered under the accumulation of ash. Similarly, in the case of the muscle, if the waste products are not adequately removed by the blood stream, they accumulate in the muscle, interfering with its further contraction, the resulting condition being known as *fatigue.*

Results of Muscular Exercise.—These events just described may be termed the local effects of muscular

exercise, because they are confined to the muscle or group of muscles actually contracting. But muscular exercise also leads to certain general effects which affect the whole body.

Deeper breathing.—Since the contracting muscles demand a good supply of oxygen and have need to get rid of carbon dioxide, the breathing becomes deeper and quicker.

More rapid circulation.—The heart beats more forcibly and more rapidly, in order to speed up the circulation, to convey to the muscles oxygen and glycogen and to remove from them lactic acid and carbon dioxide.

Sweating.—As muscular exercise leads to the production of heat, sweating occurs in order to cool the body by the evaporation of sweat from the surface. This last effect may be harmful and lead to catching cold, unless care is taken to prevent the body cooling too rapidly. These general effects of muscular exercise are familiar to everyone, and occur within a short time of taking the exercise.

General development.—A fourth effect occurs more gradually and only in response to frequently repeated exercise. If demands are made upon the muscles regularly and often, the muscles generally respond by growing bigger and stronger: they undergo what is known as development. Injudicious exercise of muscles may lead to overstrain instead of development and this applies particularly to the heart muscle.

Value of Organized Exercise and Games. — The foregoing remarks hold good for all kinds of muscular exertion, but when this exertion is made in the form of organized games and exercises, certain benefits may be derived.

Physiological changes.—The various physiological changes occur as before and many of these (such as deep breathing) are beneficial to the body as a whole.

Change from bookwork.—Games and exercises in school life also form a valuable change from bookwork, resting the eyes and dispelling boredom.

Training in co-ordination.—Games which involve the handling of apparatus, such as balls or bean bags, afford training in what is known as co-ordination between mind and muscle. Co-ordination will be better understood by considering a familiar example. When first you learn to play tennis you may have read a great deal about the game and watched experts play, so that you know in your mind exactly what you want to do. But when you get on the court, you find you are clumsy in handling your racquet because your arm muscles do not obey your mind with promptness and precision. After much practice, these muscles become better educated or co-ordinated and obey the mind more readily and more precisely, so that you are able to play tennis much better. Training in co-ordination is valuable in young children, who have not yet acquired exact control over their muscles. In older people, however, practising the highly specialized movements of such a game as tennis is not of great educational value, since it only fits them to play some more tennis, because the muscular education cannot readily be transferred to some other occupation such as drawing or painting.

Moral value.—Finally, games and exercises in which a child participates as a member of a team or group are credited with affording training in self-control, discipline, team-spirit and other moral qualities. This aspect is largely overestimated, as it is common experience that a selfish child generally remains selfish in spite of lengthy participation in team games.

CHAPTER 5

THE BLOOD AND CIRCULATION

In a previous chapter it has been shown that the muscles and other organs of the body require for their activities a supply of food material and oxygen. Furthermore, these organs are continually producing waste matter, notably carbon dioxide. The food material and also the oxygen are carried round the body in a liquid, the *blood*, which flows to all parts in a series of pipes, the *blood vessels*. Similarly, the waste products are removed from the organs forming them by means of the *blood stream*. The principle is that seen in a town or city where each house is served by pipes supplying fresh water and by other pipes carrying away the sewage.

The Blood. *Plasma.*—When blood flows from a wound it appears as a red, somewhat sticky liquid, but if it is examined under the microscope, it no longer has this familiar appearance. Microscopic examination shows that the liquid part of the blood is not red, but of a pale yellow colour, and in this liquid float a large number of minute solid particles, some of which, being red, give the characteristic colour to blood. The liquid is termed plasma, and the solid particles are termed *corpuscles*, a Latin word meaning " little bodies."

Red corpuscles.—The majority of these corpuscles are simply minute discs (Fig. 21) of a yellow or orange tint. When seen in the mass they appear red and so they are termed red corpuscles. There are about 5,000,000 red corpuscles in each cubic millimetre of blood. The red corpuscles contain a chemical substance known as *hæmoglobin.* This substance has the property of combining with

oxygen and later on releasing the oxygen again. Therefore, as the blood flows through the lungs, the haemoglobin in the red corpuscles takes up oxygen from the air which has been breathed into the lungs. Then, as the blood flows through different parts of the body, the hæmoglobin releases the oxygen to supply the muscles and other organs which need it for their work. When hæmoglobin is combined with oxygen it has a brighter red colour than when it is not so combined, consequently pure blood (that which contains much oxygen) is bright red and impure

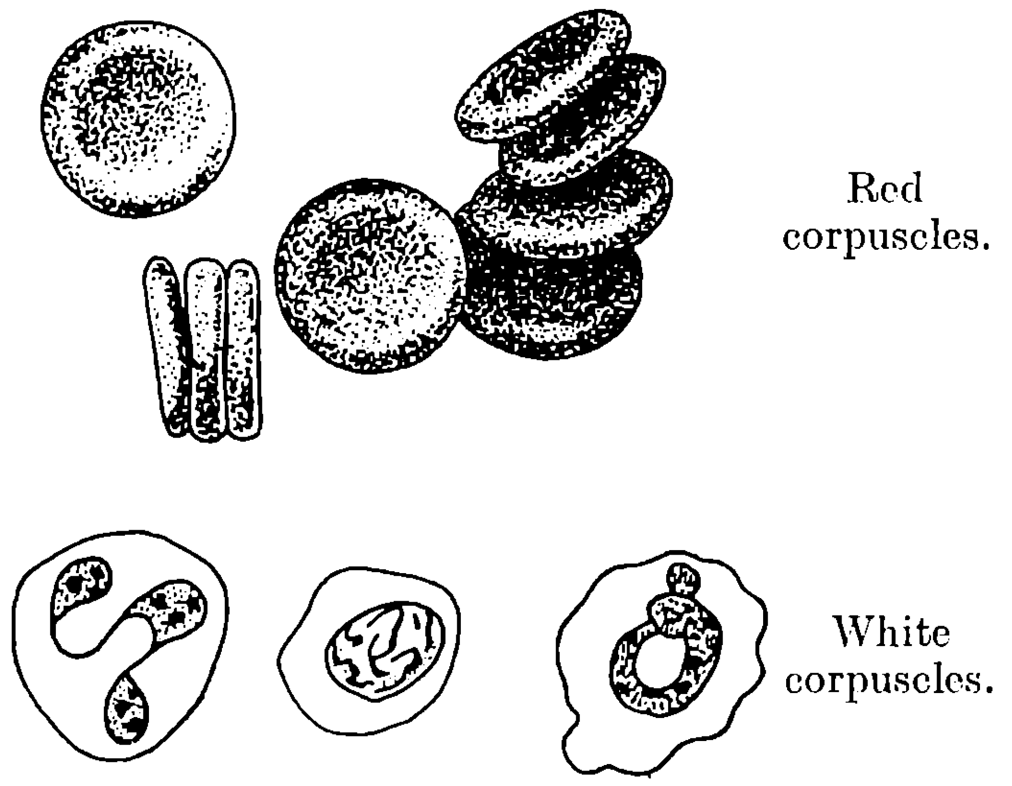


FIG. 21.—Blood corpuscles.

blood (containing carbon dioxide but little oxygen) is dark red, almost purple.

White corpuscles.—In addition to red corpuscles, the blood contains other, colourless, bodies commonly termed white corpuscles, although " colourless " is a more accurate description (Fig. 21). The white corpuscles resemble the amœba, not only in general form, but in their ability to move about by means of false limbs or pseudopodia. There are about 6000 of them in a cubic millimetre of blood. Since they contain no hæmoglobin, the white corpuscles have nothing to do with carrying oxygen in the blood stream, but some of them play an important part in keeping

the body free from germs and other impurities. When such harmful particles enter the body, certain white corpuscles hurry to the spot and devour the invaders in much the same way that an amœba devours its food. For this reason these white corpuscles are termed *phagocytes*, a combination of two Greek words meaning " eating cells." They are, in fact, the scavengers of the body. It is beyond the scope of this book to discuss the work of the other white corpuscles which are not phagocytic.

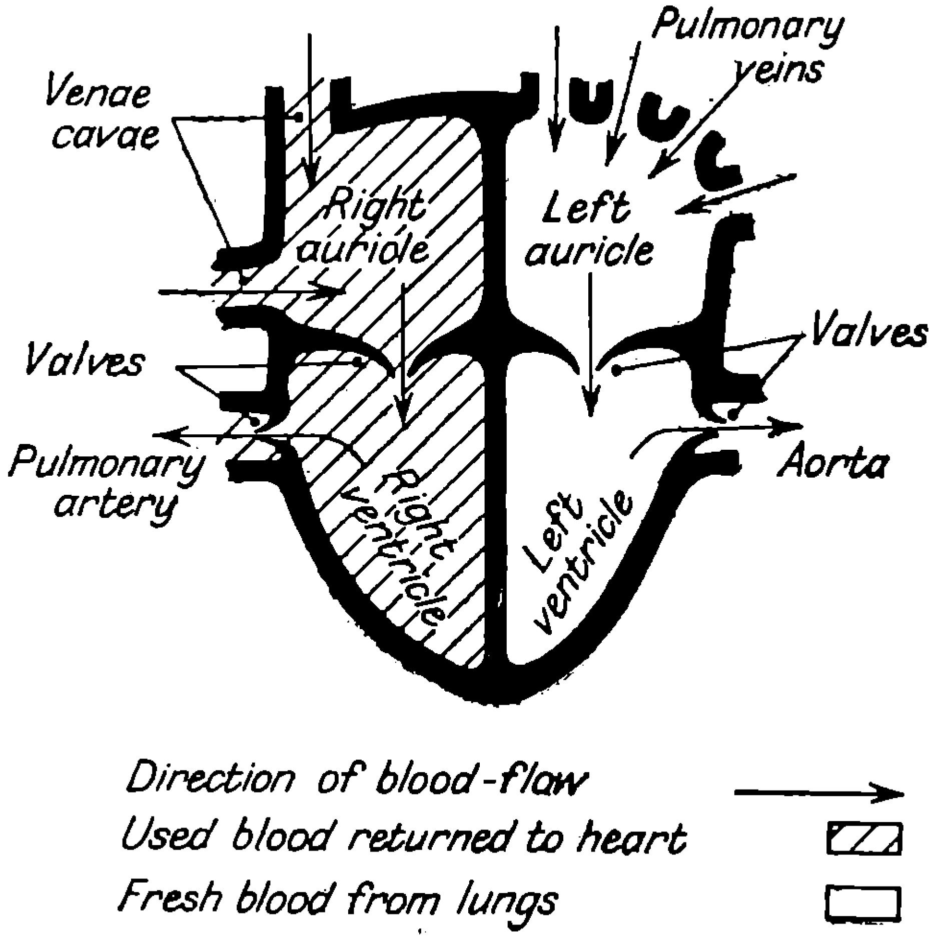


FIG. 22.—The heart (diagrammatic).

The Heart.—The term *circulation* implies that the blood moves round and round the body, coming back always to the place from which it started. This is actually the case. If it were not so, the blood would be of no use, either for conveying oxygen and food material or for removing waste products. The blood is kept circulating by the action of a pump, the heart, which is a roughly pear-shaped organ lying in the chest, almost in the middle line, but with a slight preponderance to the left. It is impossible in a book of this type to give an adequate description of the appearance and structure of the heart and, if it were

possible, such a description would serve to confuse rather than to make clear the way in which the heart does its work. In spite of its anatomical complexity, the principles underlying the working of the heart may be reduced to very simple terms, and may readily be understood by reference to Fig. 22.

Chambers of the heart—The heart is simply a bag made of muscle and, like muscle cells elsewhere in the body, those in the heart have the power of contracting, becoming shorter, and then relaxing, being restored to their original length. When the heart muscle contracts the bag naturally becomes smaller and blood, with which the heart is filled, tends to be squeezed out of various openings provided by Nature in the heart wall. The heart is not, however, a simple muscular bag, but is divided by a strong, fibrous partition into two halves, right and left. The two sides of the heart do not communicate with one another in any way. Each half is further subdivided into two chambers by a partition running from side to side, but this time there are spaces in the partition enabling the upper and lower chamber on either side to communicate with one another. The two upper chambers are termed the right and left *auricles* ; the two lower chambers the right and left *ventricles*.

Action of the heart.—The way in which the heart acts as a pump can best be understood by following the course which the blood takes from the time it enters the heart until it finally leaves it for its journey round the body. Blood which has already circulated round the body, which contains carbon dioxide and is relatively poor in oxygen, is brought to the right auricle in a number of tubes termed *veins* (Figs. 22 and 23). The blood trickles from the veins into the auricle until this cavity of the heart is filled, and then the heart muscle begins to contract to make the heart as a whole (and incidentally the right auricle) smaller. This results in blood being squeezed out of the auricle again. It does not, however, return to the veins, because the contraction of the heart muscle squeezes the mouths of the veins (where they open into the auricle) and so effectively

narrows them. Consequently, the only route which the blood can take to escape from the auricle, in response to the pressure of the contracting heart, is through the opening into the right ventricle. When the right ventricle is filled with blood further contraction of the heart causes this chamber to be pressed upon and, as before, blood is squeezed out. The blood does not return to the right auricle because the opening between auricle and ventricle is guarded by small, fibrous tags which hang down into the

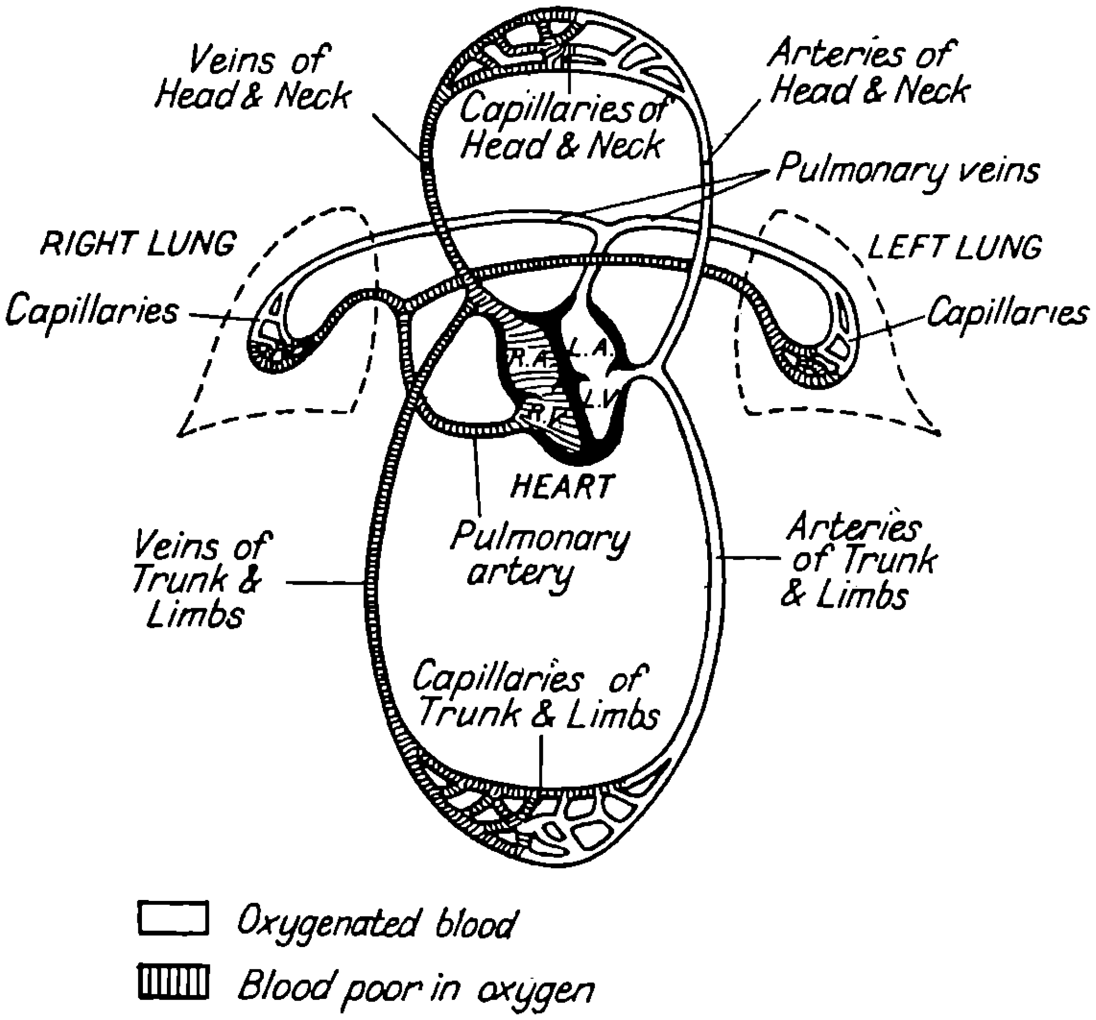


FIG. 23.—Scheme of the circulation of the blood.

ventricle something like a pair of trap-doors. As long as the blood travels from auricle to ventricle (the proper direction) these trap-doors do not impede its progress. As soon as the blood attempts to travel from ventricle to auricle (the wrong direction) the stream of blood washes these trap-doors together, and so blocks the opening. In other words, if the blood tries to go the wrong way, it automatically slams the door on itself. This arrangement for one-way traffic is termed a *valve*. Because of this valve, the blood can only escape from the right ventricle through

the opening marked *pulmonary artery* in Fig. 22, the beginning of a tube which conveys the blood to the lungs.

Circulation in the Lungs.—This tube is termed the pulmonary artery, *pulmo* being the Latin word for the lung. The pulmonary artery divides into two branches, one going to each lung, and inside the lung the artery divides and subdivides into smaller and smaller branches until the final divisions are minute blood vessels termed *capillaries.* The Latin word *capillus* means a hair, so capillary suggests that these little blood vessels are as fine as hairs. Actually they are much finer than the finest hair imaginable, so small that they cannot be seen except by means of the microscope. The lungs contain millions of these minute blood vessels, and they line the walls of air spaces in the lungs so that here the blood in the capillaries and the air in the air spaces are in very close contact. The oxygen readily diffuses from the air through the walls of the capillaries into the red corpuscles and carbon dioxide similarly escapes from the blood into the air. The capillaries then unite with one another, forming larger and larger vessels, until finally a number of large tubes termed *pulmonary veins* emerge from each lung and run to the left auricle, carrying pure blood to the heart.

The General Circulation.—The contraction of the heart now causes blood to flow from the left auricle to the left ventricle through a valve in precisely the same manner as was previously described in the case of the right side of the heart and, of course, the pure blood is being squeezed through the chambers of the left side of the heart at the same time that impure blood is passing down the right side. From the left ventricle the pure, oxygenated blood enters a large blood vessel called the *aorta.* This vessel divides into branches, the arteries, which convey blood to all parts of the body, some running through the neck to the head, others into the limbs and others to various parts of the trunk. The arteries divide and subdivide into smaller and smaller branches, until finally they form capillaries in all parts of the body exactly as the pulmonary artery does in

the lungs. In the general capillaries of the body an exchange of gases, of food and of waste products between the blood and the body cells takes place. Oxygen and food material escape from the blood, carbon dioxide and other waste products enter the blood stream. The capillaries unite with one another, forming larger and larger vessels, the veins, until the largest veins of all, the *venæ cavæ* (singular, vena cava) enter the right auricle of the heart as previously described. So the circulation of the blood is complete.

It should be noticed that the blood travels round two separate circuits. One of these takes it through the lungs by means of the pulmonary arteries, capillaries and pulmonary veins. The other, and much longer circuit, covers the rest of the body by means of the aorta, the arteries, the capillaries, the veins and the venæ cavæ. The vessels which carry blood away from the heart are termed arteries and, with the exception of the pulmonary artery, these vessels contain pure, oxygenated blood. The vessels carrying blood towards the heart are termed veins and, with the exception of the pulmonary veins, the blood which they contain is impure and poor in oxygen.

Arteries.—The action of the heart in contracting and relaxing is spoken of as the *heart beat*, and this beating can readily be felt on placing the hand over the left side of the chest. It occurs about seventy-two times per minute in an adult when sitting or lying quietly and not performing any vigorous muscular movement. The pumping of the heart forces the blood into the aorta and so into the various arteries with considerable force, so wherever an artery happens to be near the surface of the skin, a throbbing (the *pulse*) can be definitely felt at each beat of the heart. This pulsation is most commonly felt in front of the wrist at the root of the thumb. It can also be felt in the region of the ankle, the groin, the temple and in a number of other places.

Capillaries.—The blood is squirted out of the arteries into the capillaries with all the force of the heart behind it, and at this point is a rapidly moving stream. Once in the

capillaries, the rapidity soon dies away and the blood finally enters the veins as a very slow moving stream. The reason for this can be seen by reference to Fig. 24. The first diagram represents a river widening to form a lake and then narrowing again to continue as a river. When the water enters the lake (at point A) it is moving very rapidly, but since the surface area of the lake is much greater than that of the river, the force of the current soon dies away and, when the water leaves the lake (at point B), the stream is moving only slowly. In the second diagram the lake is represented as containing a large number of islands, so that

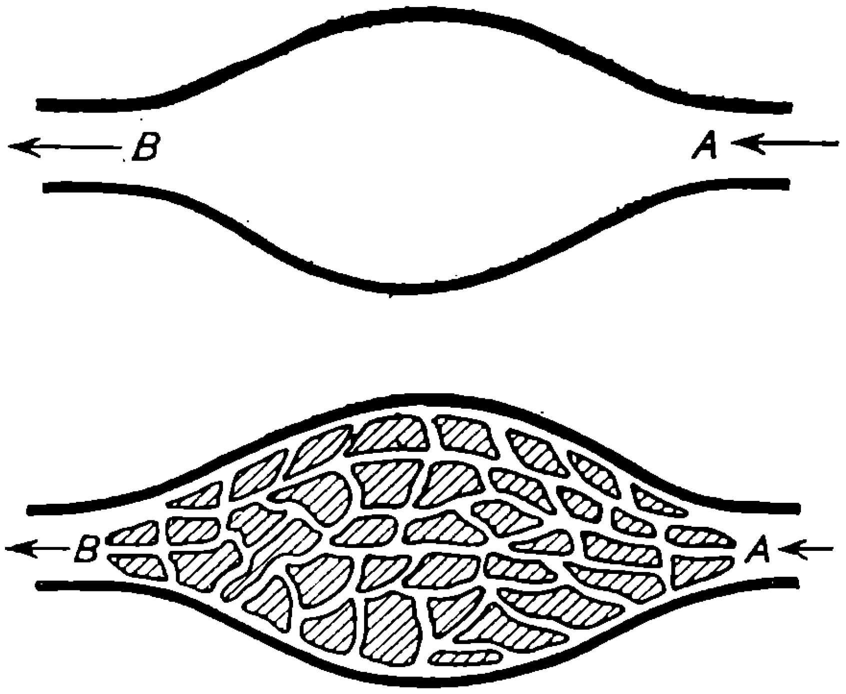


FIG. 24.—Diagram of capillaries.

instead of a broad expanse of water there is a large number of separate channels. Nevertheless, the combined surface area of these smaller channels is much greater than that of the main river, and so between A and B the force of the current is greatly diminished as in the first example. Now this second diagram can also represent a small artery dividing at point A into a number of capillaries, which reunite at point B to form a small vein. Although each capillary is much smaller than each artery, yet the combined capacity of all the capillaries in the body is much greater than that of the arteries. In consequence of this, although the blood enters the capillaries as a rapidly flowing stream, it leaves them and enters the veins moving very slowly.

Veins.—Since the blood in the veins is flowing with very little force behind it, Nature has had to adopt special means for ensuring that the blood flows on towards the heart. This applies particularly to the legs, where the blood in the veins has to ascend against the force of gravity. Inside the veins, particularly the leg veins, at short intervals, are small fibrous tags forming valves just like the valves in the heart (Figs. 25 and 25A). These little trap-doors

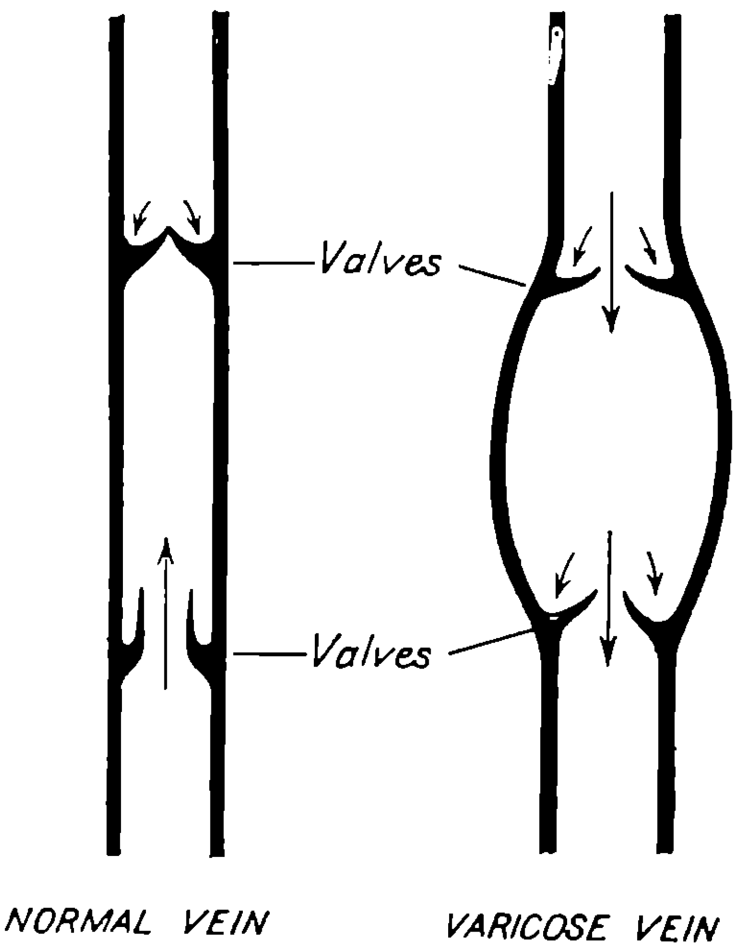


FIG. 25.—Valves of veins.

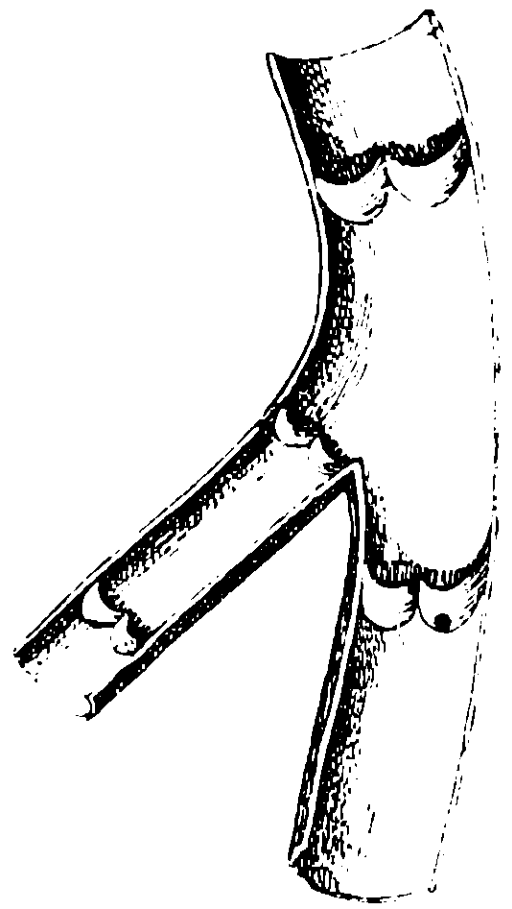


FIG. 25*a*.—Vein cut open to show valves.

allow the blood to travel in the right direction but prevent it from flowing in the wrong direction. The veins are tubes with comparatively thin walls and they wind a somewhat tortuous course amongst the ordinary voluntary muscles of the body. When a muscle contracts (for instance, in the leg) it becomes fatter, as has been shown in a previous chapter. In becoming fatter it naturally presses upon the veins in its immediate vicinity, and this squeezes the blood along the vein away from the point on which the muscle is pressing. Because of the presence of valves inside

the vein, the flow is always in one direction, towards the heart. If a person wears tight bands round the limbs (for example, tight garters) these press upon the veins and prevent the free flow of blood inside them. Capillaries, however, continue delivering blood into the veins and in order to hold the excess of blood the walls of the veins stretch (Fig. 25). When this occurs the valves no longer fit accurately together when closed and so blood is enabled to travel in the wrong direction. This state of affairs is termed *varicose veins*. It is commonly seen in people who wear tight garters or other constricting bands round the legs, particularly if they have an occupation which necessitates standing about all day without any vigorous exercise, so that the muscles are not made to contract and squeeze blood out of the veins, but allow it to collect and stagnate as described.

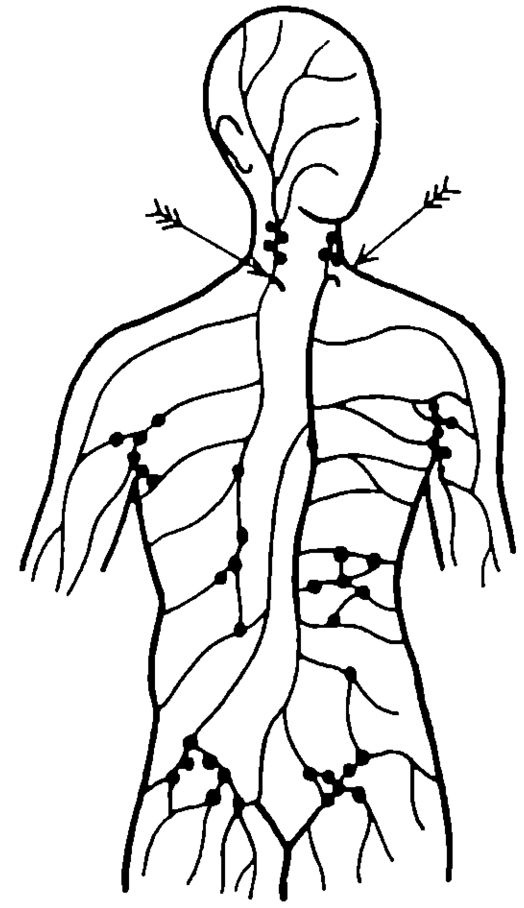


FIG. 26.—The lymphatic circulation.

Lymph. — Although there are millions of capillaries in the body, they are not numerous enough to bring the blood into close contact with every individual cell, but since the capillary walls are very thin indeed a certain amount of liquid from the blood filters through and flows freely amongst the individual cells, carrying with it some of the white corpuscles from the blood stream. This liquid carries food material, and oxygen derived from the red corpuscles, but differs in some of its chemical constituents from the blood plasma, and is called *lymph*. The constant filtration of lymph from the blood day after day might soon leave

nothing but corpuscles in the blood vessels and the blood would dry up. To avoid this it is necessary for the lymph to be collected from amongst the individual body cells and to be returned to the blood stream. This is accomplished in the following way.

Lymphatic Channels.—The lymph finds its way into minute channels (very much like capillaries) termed lymphatic channels (Fig. 26). These unite with one another, forming larger and larger channels, those from the limbs joining others in the trunk, until the largest lymphatic

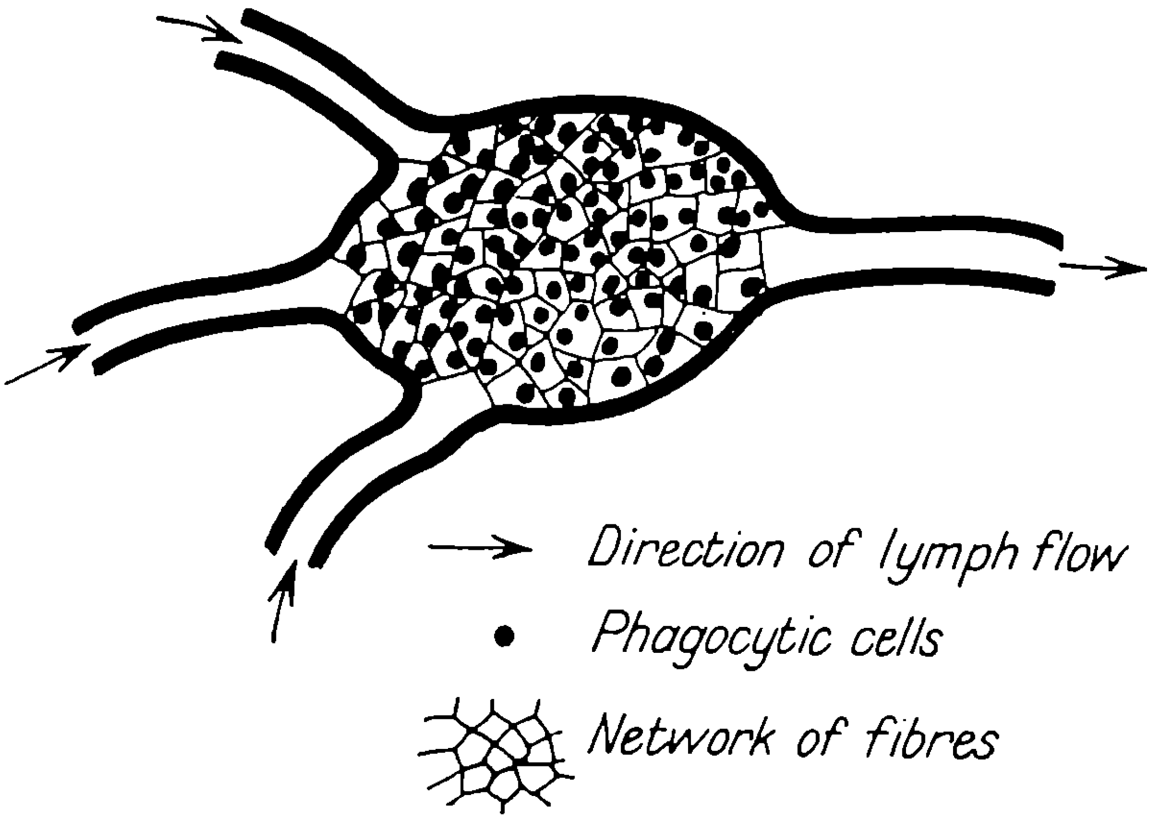


FIG. 27.—Diagram of lymphatic gland.

channels in the body join certain of the veins in the region of the neck, and in this way the lymph returns to the blood stream.

Lymphatic Glands.—At various points in the body where several lymphatic channels join together, small, fleshy knobs are found about the size of a pea. Under the microscope (Fig. 27), these little knobs (*lymphatic glands* as they are called) are seen to consist of a network of fine fibres, in the meshes of which numerous phagocytes are entangled. The lymphatic glands act as filters to the lymph as it flows through them, germs and other impurities

being filtered out and devoured by the phagocytes. It sometimes happens that the germs in a lymphatic gland overcome the phagocytes, and in this case the gland becomes swollen and painful. The best known sites of lymphatic glands are the neck, arm-pits and groins, and children not infrequently suffer from swollen glands in these regions.

CHAPTER 6

BREATHING

We have seen that the blood carries oxygen and food material to the tissues of the body and removes from them certain waste products such as carbon dioxide. We have now to see how the oxygen gets into the blood and how the carbon dioxide gets out of it in the process known as *breathing* or *respiration*.

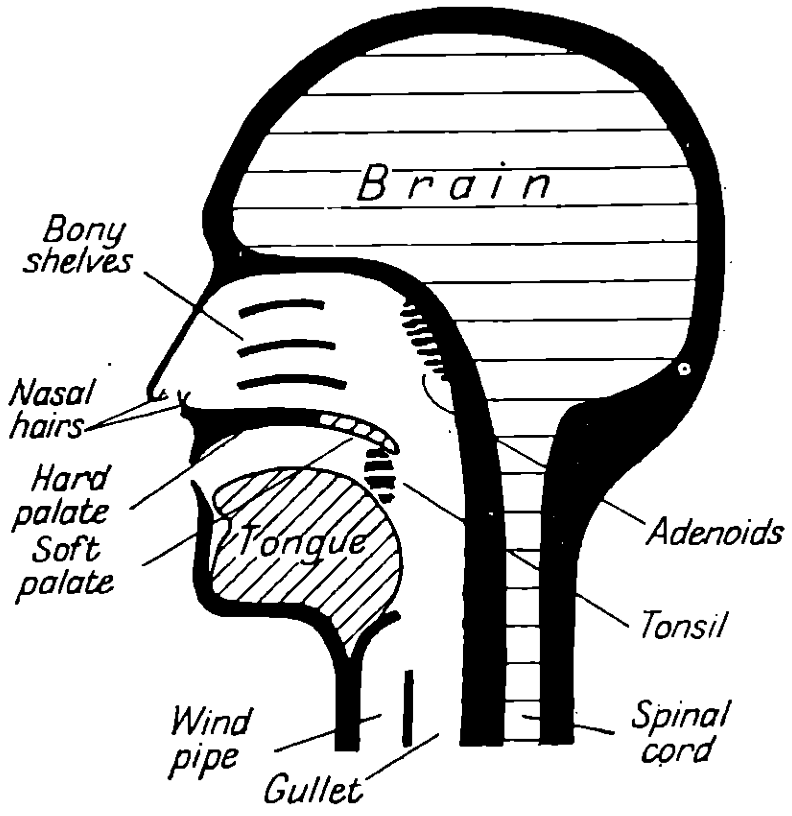


Fig. 28.—The head and neck in section.

The simplest way to understand the respiratory system is to follow the course that the air takes from the time it enters the nose or mouth until it finishes up in the depth of the lungs.

The Nose.—Fig. 28 is a sectional view through the head and neck. For the sake of clarity most of the details are omitted, but certain details are shown in the region of the

nose and mouth. The nose includes not only the familiar projection upon the face, but also a cavity in the skull to which reference has been made in an earlier chapter. The roof of this cavity is a plate of bone which also forms the floor of the cranium or brain box, and separates the nose from the brain. Below the nose is the *mouth.* If the finger is introduced into the mouth behind the upper teeth and pressed upwards, a resistance is felt due to the *hard palate,* a bony structure forming the roof of the mouth and, at the same time, the floor of the nose. As the finger travels backwards, this resistance ceases when the *soft palate* is reached, since this is made of flesh and contains no bone.

On breathing in, the air first enters the nostrils and comes into contact with a number of short, stiff hairs. In human beings these hairs are not of much importance, but in many lower animals, particularly those which browse in long grass, the nasal hairs serve to keep out insects.

When the air enters the nose, it is relatively cold compared with the temperature of the body, but if cold air was allowed to enter the lungs it would tend to lower the body temperature and might well prove harmful. Nature, therefore, attempts to warm the incoming air by the following device. Three plates or shelves of bone project from the side wall of the nasal cavity on each side (they are seen edge on in the diagram, and are represented by three lines). These bony shelves are covered by a network of capillaries containing blood which is, of course, at the body temperature. As the air flows over the shelves it is warmed by contact with the hot blood, just as in a building the air enters through a grating in the wall and passes over a radiator or hot water pipes immediately inside, thus becoming warm before being dispersed throughout the room. Referring to Fig. 28, it will be seen that the incoming air tends to strike upon the back wall of the nose. The lining of the nose is generally smooth and pink like the interior of the mouth, but in this region, at the back of the nose, it is somewhat soft and spongy. In the nooks and crannies of the spongy part of the nasal lining there are many

phagocytes similar to those found in the blood. The whole forms a device for purifying the air, since the incoming air deposits here germs and dirt which it may contain. The phagocytes then devour these impurities, so that the air continues on its way to the lungs purified as well as warmed.

Adenoids—In health, this cleansing arrangement has no special name given to it, but sometimes the germs over-

Fig. 29.—A child suffering from adenoids (by permission from Fraser's *Surgery of Childhood*).

come the phagocytes, giving rise to a diseased condition, which results in swelling of the lining of the nose at this point, the result being termed *adenoids*. Adenoids is, therefore, the name of a disease, and one should not speak of a child having "healthy adenoids." The adenoid mass may become so large that it obstructs the back passage of the nose, rendering breathing through the nose difficult or impossible. A child with this complaint must therefore

keep his mouth open in order to breathe, and this gives rise to a characteristic expression of stupidity which is known as the " adenoid face " (Fig. 29). For reasons which are explained in Chapter 21, deafness is often associated with adenoids and a deaf child is likely to be backward in school, since he misses much of what the teacher says. The adenoid child, therefore, not only looks stupid, but appears to be so, although actually an operation to remove the

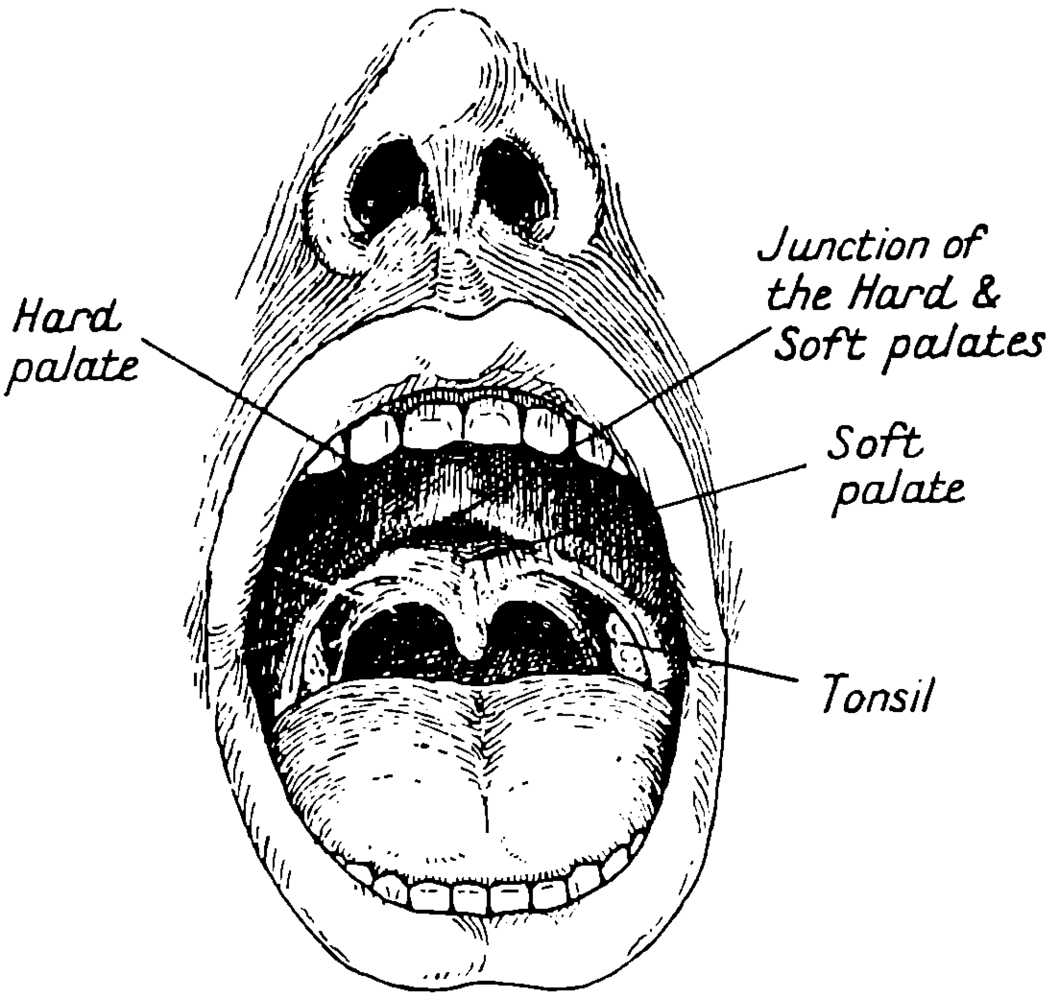


FIG. 30.—The back of the mouth.

adenoids relieves both the apparent stupidity and the foolish expression.

The Mouth and Tonsils.—Air can also be taken in through the mouth, but the mouth contains no warming device such as is found in the nose. If a breath is taken through the nose (not too vigorously) and, immediately afterwards, another through the mouth, it will be noticed that the air passing through the mouth feels colder than that passing through the nose, although actually it is the same air from the same room in each case. If the mouth

be opened wide in front of a mirror, the tongue being held down by the handle of a spoon or some similar object, the appearance shown in Fig. 30 is seen. Notice the two fleshy masses, the tonsils, in the position indicated in the figure. These are spongy masses of tissue containing phagocytes, similar to the specialized lining of the nose already described, again a device for filtering the air. Notice that tonsil is the name of a normal structure of the body which may be healthy or diseased. Adenoids, on the other hand, is simply the name of a disease, although when a child suffers from adenoids, the tonsils are generally enlarged at the same time.

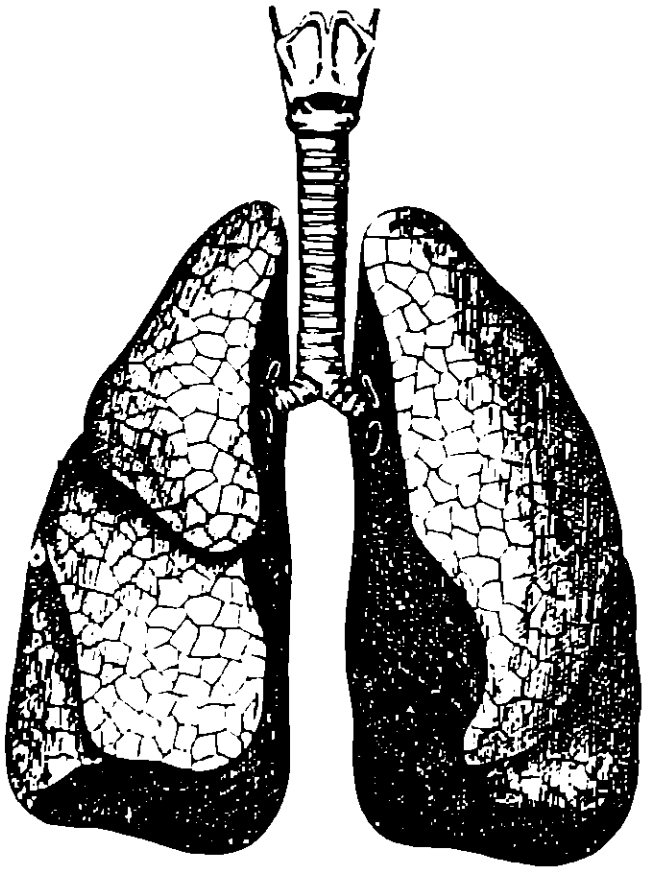


FIG. 31.—The air passages and lungs.

Since the nose filters and warms the incoming air, it is better to breathe through this organ rather than through the mouth, but after vigorous exercise, the demands for air may be so great that mouth breathing has to take place.

The Pharynx.—Both the nose and the mouth lead to a space, the pharynx (Fig. 28), from which two passages or tubes lead into the neck. One of these, in front, immediately below the skin of the neck, is the *wind-pipe*, the other is the food passage, or *gullet*.

The Wind Pipe and Bronchi.—It is of obvious importance that the wind-pipe should always be an open tube: it would not do for its walls to collapse together, thus closing it up, even for a few minutes, for breathing would be impossible and life would cease. At the same time, it must be a flexible tube to permit movement of the head and neck. In order to combine reasonable rigidity with flexibility, the wind-pipe is composed of a series of

rings of cartilage connected together by softer, fibrous material. The principle is that seen in the flexible hose of a vacuum cleaner, where patency and flexibility are also required, and such tubes are made of a series of metal rings connected together by some suitable fabric. The wind-pipe travels through the neck and into the chest. Behind the middle of the breast bone it divides into two branches

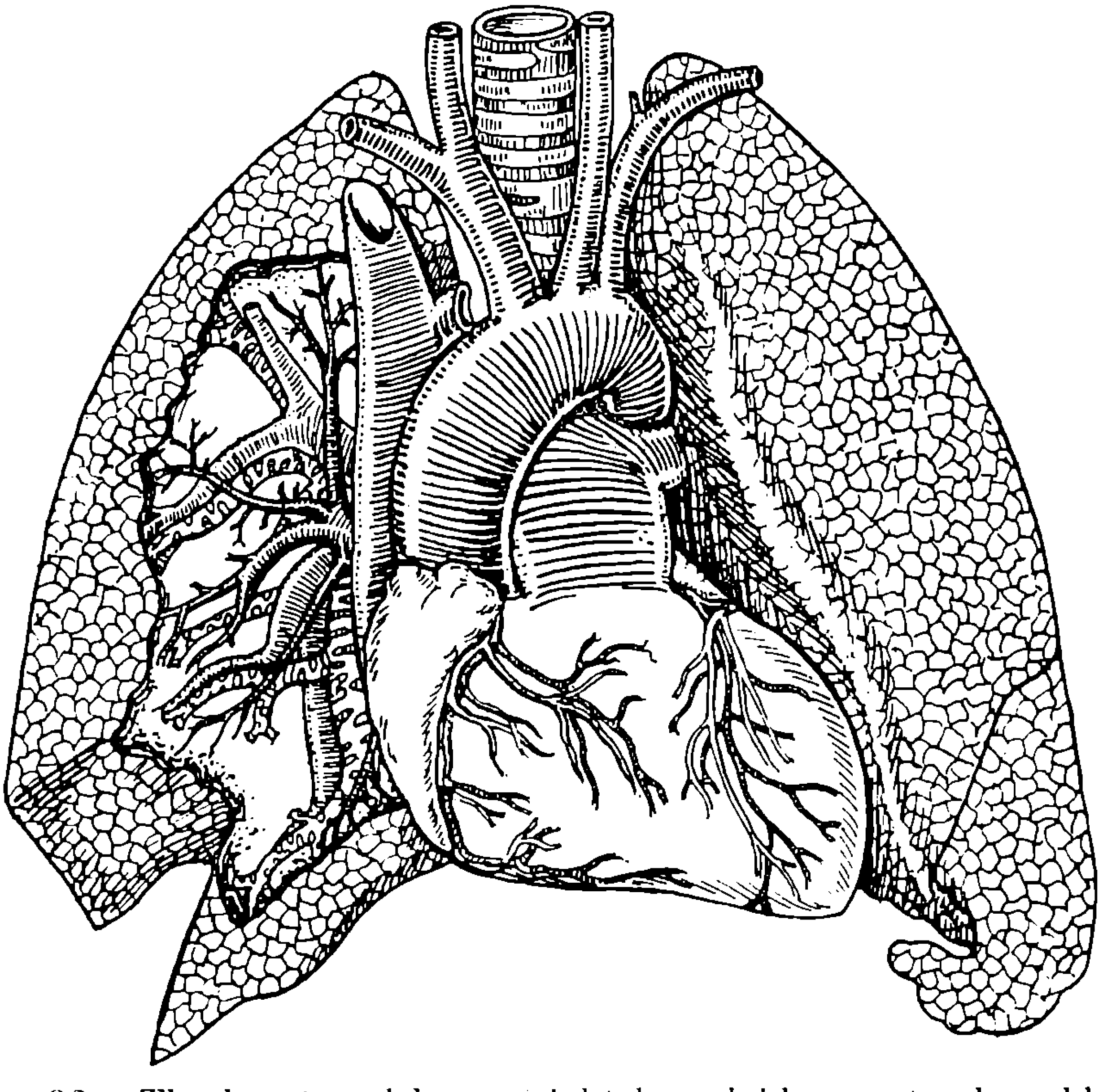


FIG. 32.—The heart and lungs (right lung laid open to show blood vessels).

which are termed *bronchi* (singular, bronchus). It is inflammation of these bronchial tubes which constitutes the complaint known as *bronchitis*. One bronchus enters each lung (Fig. 31).

The Lungs.—The lungs are two organs lying in the chest on either side of the heart (Fig. 32), and occupying the bulk of the space within the chest cavity. They may be compared to an unburstable rubber ball of the Sorbo type,

having a smooth exterior and a spongy interior, due to the large number of spaces which contain the air (Fig. 33). If the course of a bronchus is traced within the lung, it is found to divide again and again into smaller and smaller tubes until the final divisions, microscopic in size, terminate as culs-de-sac which are known as *air cells* (Fig. 34). The term air-cell sometimes gives rise to confusion. It has nothing to do with a protoplasmic or living cell. The term cell in this case means simply a small, confined space, so that an air cell is a space amongst the living cells of the lungs.

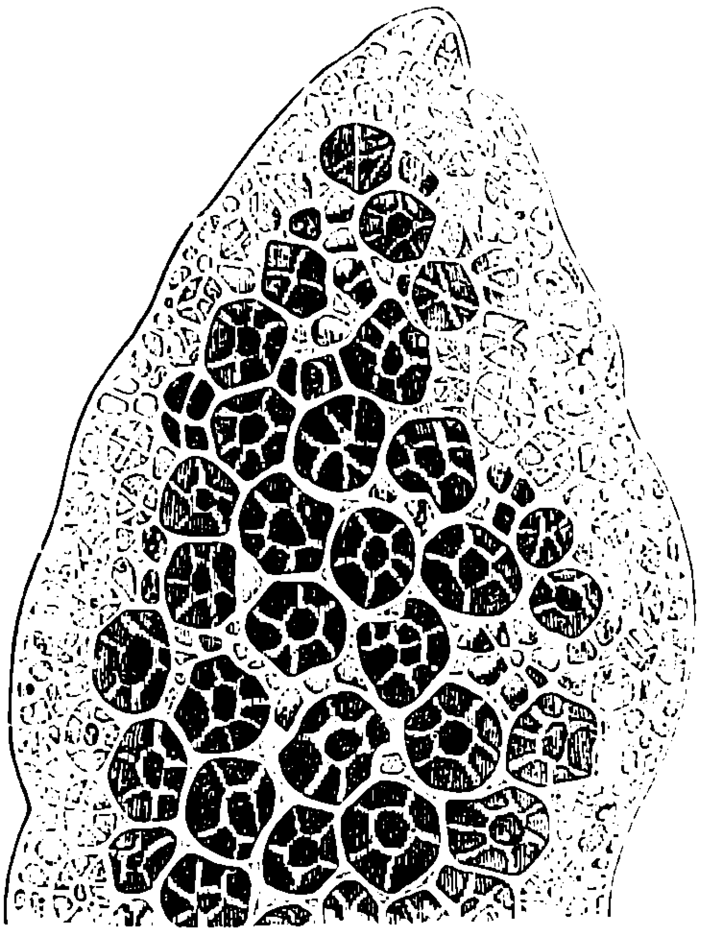


FIG. 33.—Section of lung showing air spaces.

Exchange of Gases in the Lungs.—Fig. 35 represents two air cells considerably magnified, and between them runs a small blood vessel—a capillary. It will be recalled that the blood is pumped by the heart to the lungs in order to acquire a fresh supply of oxygen. The blood enters the lungs in an impure condition and consequently is of a somewhat purple colour. As it flows through such a capillary as the one represented in the figure, the only barriers between the blood in the blood vessel and the air in the air cell are the capillary wall and the wall of the air cell. Both these structures, being of microscopic dimensions, are very thin indeed and it is an easy matter for the oxygen contained in the air within the air cell to filter through into the blood, and for the carbon dioxide to escape from the blood into the air. In this way the blood is purified and eventually leaves the lungs to return to the heart, whence it is pumped all over the body.

Mechanism of Breathing.—So far we have seen the route which the air traverses on its journey from the nose

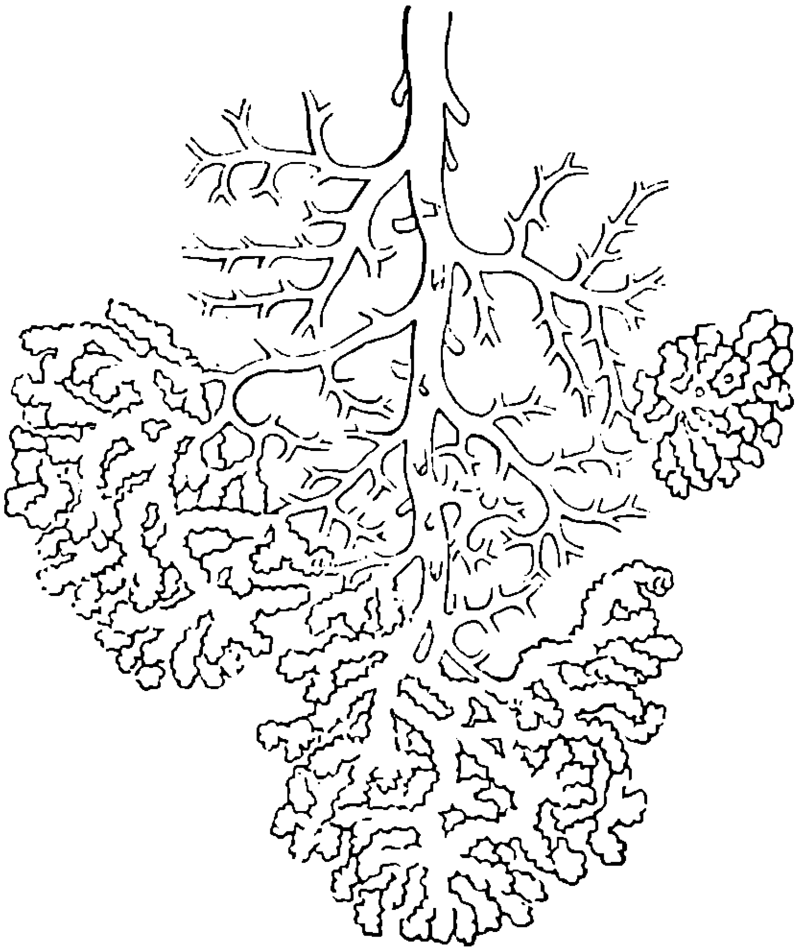


FIG. 34.—Air passage terminating in air cells.

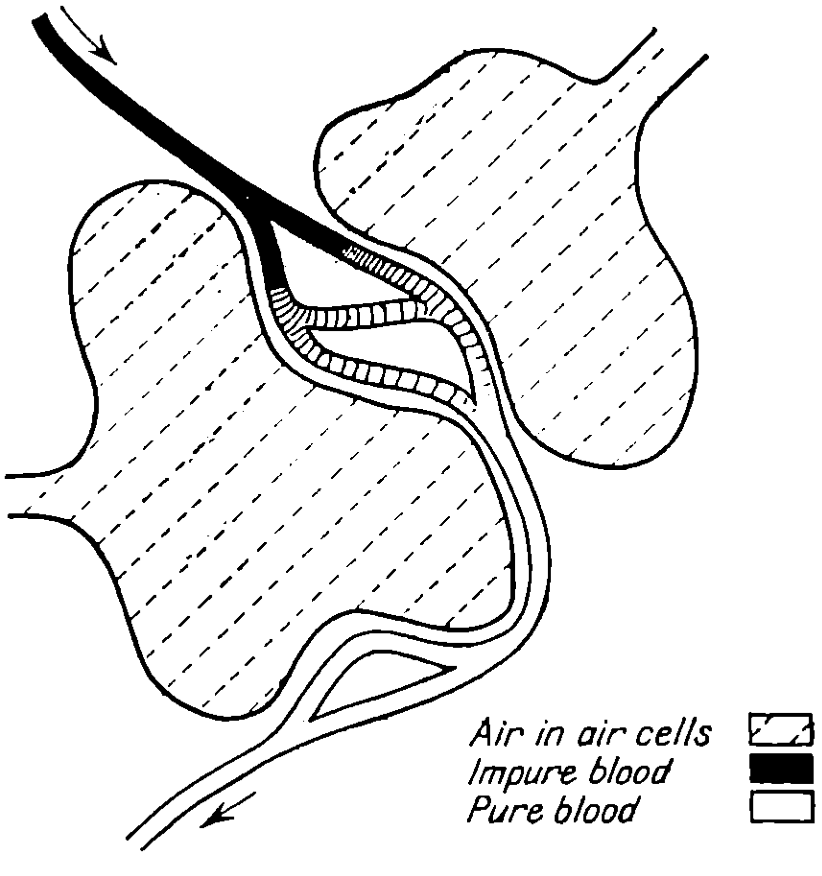


FIG. 35.—Blood vessels and air cells in the lungs.

and mouth to the lungs and in breathing out it travels, of course, in the reverse direction. We have now to consider

the mechanisms which cause the air to flow into and out of the air passages.

Action of the ribs.—Fig. 36 is a section view of the chest as it would appear if it were divided from side to side and the front removed. The divided ends of the ribs are shown and the windpipe can be seen entering from the region of the neck and dividing into two bronchi, one of which enters each lung. The internal structure of the lungs is omitted for the sake of simplicity. Notice that the spaces between the ribs are filled in by muscles attached to

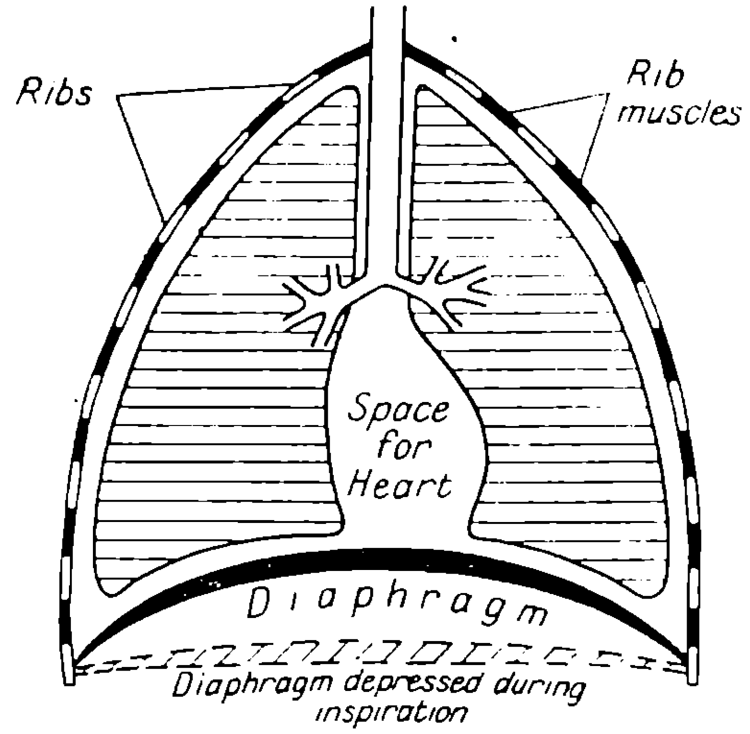


FIG. 36.—The chest in section.

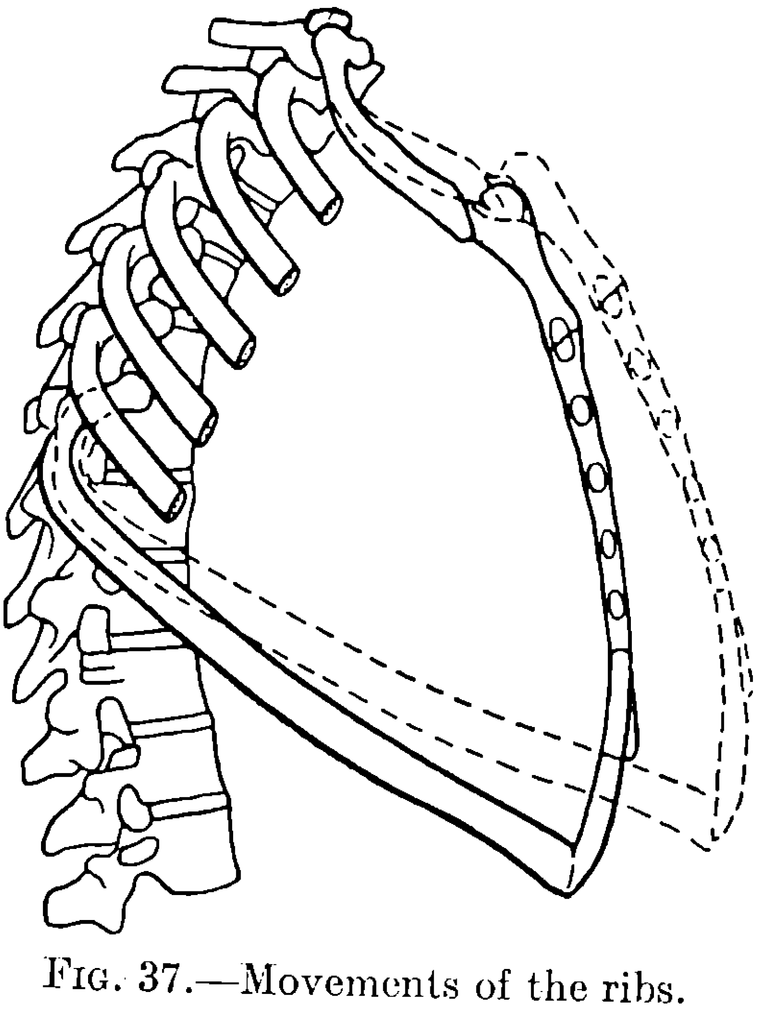


FIG. 37.—Movements of the ribs.

the upper edge of one rib and to the lower edge of the rib immediately above. When one of these muscles contracts

and becomes shorter, it naturally raises the lower rib a little nearer to the one above it and when all the muscles contract at the same time (as they do in breathing) the result is that all the ribs are raised slightly towards the head end of the body. Fig. 37 is again a section of the chest, as viewed from the side, but only two of the ribs are shown, the rest being omitted in order to keep the diagram simple. It can be seen from this figure that raising the ribs in the manner just described thrusts their front ends forward. Since the front ends of the ribs are attached to the breast bone, this bone moves forward too, that is, away from the vertebral column. The final effect is that the internal capacity of the chest is increased : there is more room between the breast bone and the vertebral column. This increase in the internal capacity of the chest tends to cause the formation of a vacuum inside and, to prevent this, air flows in down the wind-pipe and into the lungs, blowing them up so that they fill the available, increased space. The action is similar to that of a pair of bellows, such as used to be employed for blowing up a smouldering fire. When the handles of the bellows are moved apart, the bag is increased in capacity so that air flows in and fills the bellows. When the handles are pressed together, air is blown out of the bellows and this, of course, happens in the case of the chest when the rib muscles relax.

Action of the diaphragm. —The movement of the ribs is not the only device responsible for breathing. Fig. 36 shows that the chest is divided from the abdominal cavity by a sheet of muscle, the *diaphragm*, which is curved in the form of a dome. When this muscle contracts, it loses its dome shape and becomes flatter, as shown in the figure, a movement which also increases the internal capacity of the chest. These two movements of ribs and diaphragm together cause the breathing and they take place, of course, simultaneously.

The Larynx and the Voice.—It will be remembered that the wind-pipe is composed of rings of cartilage set one

on top of another. The uppermost ring is broader than the others (about an inch and a half) and is known as the *voice box* or *larynx*, since it is here that the voice is produced. Fig. 38 represents the larynx seen in section and also viewed from above. This cartilaginous chamber is lined by a thin skin or membrane, similar to the internal lining of the mouth and nose. About the middle of the voice box the lining projects inward as two folds, rather like a pair of membranous shelves. These projections are called the vocal cords, in spite of the fact that they resemble

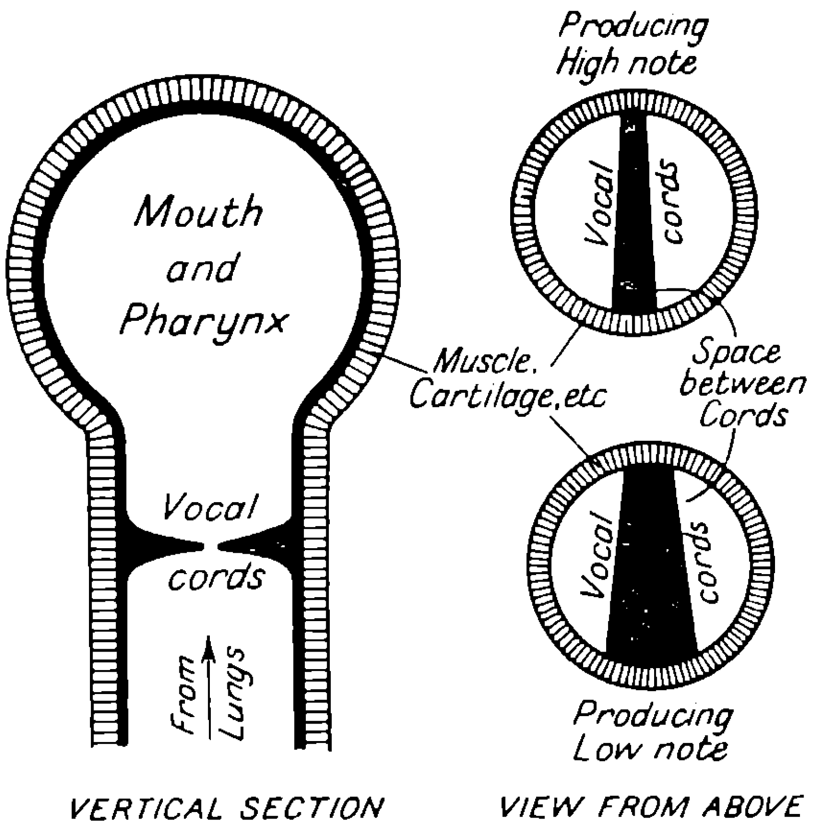


FIG. 38.—Diagrams of the larynx.

shelves rather than cords. The *vocal cords* contain a number of muscle cells and the contraction and relaxation of these cells produce movements of the vocal cords, thus the cords may be tense or relaxed, while their edges may be close together or far apart. As the air is breathed out of the lungs, it passes up the wind-pipe and through the larynx, causing the vocal cords to vibrate, and thus producing a sound which we term the *voice*. When the cords are tense and close together, a high pitched note is produced. When they are relaxed and far apart, the note is of lower pitch. In other words, the shriller the voice, the

more muscular effort is needed to make the vocal cords tense, so that teachers and others who have to use the voice a great deal should cultivate the lower tones, since these tones involve less muscular effort, and consequently less risk of fatiguing the vocal cords. Whether the voice is loud or quiet depends upon the volume of air which is blown out of the lungs. Many animals besides man have a voice and can make sounds, but man is able to shape the sounds into words by movements of the lips and tongue.

CHAPTER 7

THE DIGESTION OF FOOD

The Alimentary Canal.—Look at Fig. 39; it represents a barrel with a pipe running through from end to end. This arrangement is also shown in section. If a stone is dropped into the pipe at the top, it can fall right through and out at the other end without ever having been inside the barrel at all. The barrel represents the human body and the pipe represents the principal part of the digestive

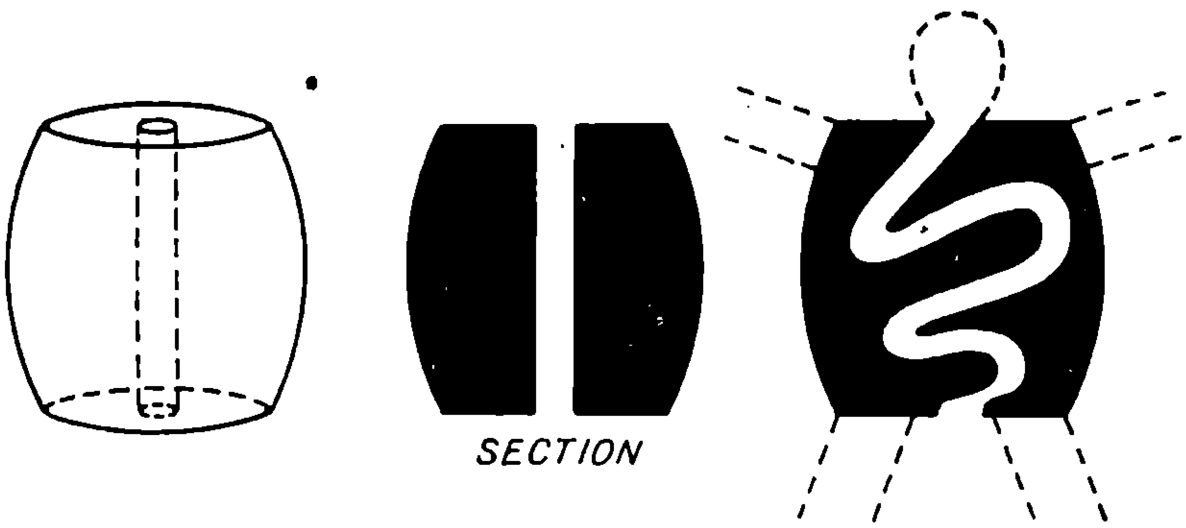


Fig. 39.—The digestive tube in relation to the body.

system, a fleshy, flexible tube running from one end of the trunk to the other. This tube is called the *alimentary canal.* When some food is placed in the upper end of the tube, that is, of course, in the mouth, it is quite possible for the food to travel right through the alimentary canal and out at the other end without ever having been inside the body proper. In other words, the interior of this tube is as much a surface of the body as is the skin. The only way in which food can get into the body to nourish the body cells is by becoming dissolved and suitably changed into a state in which it can pass through the walls of the ali-

mentary canal and so enter the blood stream. It is this process of liquefaction and alteration of the food which is termed *digestion.* The alimentary canal of a human being is a tube about thirty feet in length and, since this length of tubing has to be tucked away in a body which is not more than three feet in length, it follows that it has to be considerably twisted, coiled up and packed together. Some indication of this is shown in Fig. 39, but in reality the

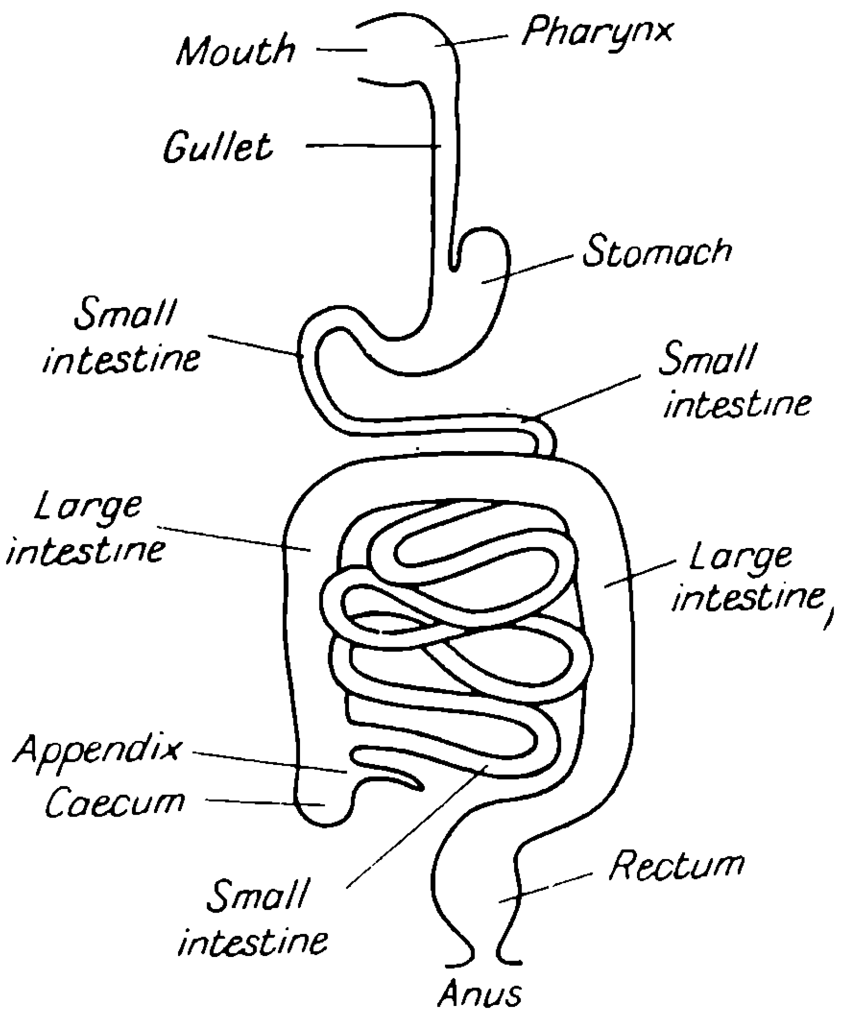


FIG. 40.—The alimentary canal.

coiling and twisting is more involved than this diagram suggests.

Regions of the Alimentary Canal.—The alimentary canal is not a simple tube, but varies in structure, diameter and appearance, at different parts of its length. Fig. 40 represents the alimentary canal as it might appear if removed from the body and unravelled from much of its complexity. The first part of the alimentary canal is the mouth and behind this lies the throat or pharynx. This part of the canal is a common passage for food and for air

and has already been mentioned in Chapter 6. It will be recalled that from the lower end of the pharynx the windpipe leads down through the neck and into the chest. Behind the windpipe lies the food pipe or gullet, which also leads through the neck, through the chest (passing between the lungs and behind the heart), through a hole in the diaphragm and into the cavity of the *abdomen*. Here the alimentary canal suddenly becomes much wider for its next eight or nine inches, forming a sort of pouch or bag, the *stomach*. Notice that the term stomach properly applies only to this portion of the digestive tube. The term should not be used as a synonym for abdomen, which is the whole of the space inside the trunk below the diaphragm. After the stomach, the alimentary canal again becomes narrow, about three-quarters of an inch in diameter, and continues thus for about twenty feet, forming the portion known as the *small intestine*, or *small bowel*. The term "small" is applied to this part of the canal on account of its diameter, and has nothing to do with its length. As can be seen in the diagram, the small intestine is the most coiled and twisted portion of the whole of the alimentary canal, the far end of it ultimately emerging from amidst this tangle in the lower right-hand corner of the abdomen, immediately above the point where the thigh joins the trunk. Here the alimentary canal becomes wider, about two inches in diameter, and the next six feet forms what is known as the *large intestine* or *large bowel*. The large intestine runs first of all up the right side of the trunk, then from right to left, just below the diaphragm, and then down the left-hand side. The terminal portion of the large intestine is wider than the rest and is termed the *rectum*.

Movement in the Alimentary Canal.—Food takes about eighteen hours to travel along the alimentary canal from one end to the other, and clearly it does not fall through by the force of gravity, since it has to turn round many corners, sometimes travelling upwards instead of downwards and, moreover, one can easily swallow and digest food when lying down, or even when standing on the

head. The mechanism by which food is caused to travel along the digestive tube is indicated in Fig. 41. The whole of the alimentary canal is made of muscle : it is a muscular tube. This muscle is of the type known as involuntary muscle, which was described in Chapter 4. The muscle cells are arranged end to end round the alimentary canal, forming a succession of muscular rings along its length. Fig. 41 represents any part of the alimentary canal from the gullet to the rectum and a mass of food is indicated inside it. It will be recalled that involuntary muscle contracts when stretched and the presence of food within the digestive tube causes a mild degree of stretching. When this occurs, the muscle immediately behind the mass of food (that is, between the food and the mouth) contracts, thus narrowing the alimentary canal in that region. The contraction is taken up by the next ring of muscle and then by the next, travelling along the alimentary canal something like a wave and pushing the mass of food before it.

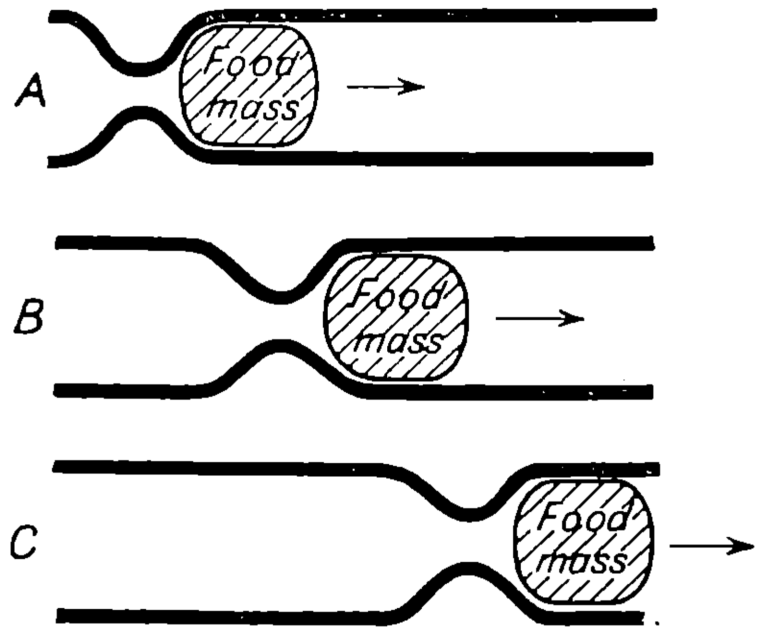


FIG. 41.—Movement of food in the alimentary canal.

This, then, is a general outline of the digestive system, but it is now necessary to consider the various parts separately and in more detail.

Mouth.—The mouth contains the *teeth*, which chew and grind up the food (see Chapter 22), and it also contains the *tongue*, which has two tasks to perform. First, the tongue is the means by which we taste the food (see Chapter 9), and second, the movements of the tongue cause different parts of the mouthful of food to be thrust under the teeth in turn.

Pharynx.—The food passes through the pharynx into the gullet. Notice that it has to cross the open end of the

windpipe. During the actual act of swallowing, however, the breath is held for a moment, and a ring of muscle which runs round the upper end of the windpipe, like a purse string round the top of a purse, contracts, thus narrowing down the entrance to the air passages, and so the food, generally speaking, takes the proper course into the gullet. Occasionally, however, a small crumb does go down the wrong way, giving rise to a bout of coughing until it is expelled.

Gullet.—The gullet or food passage extends from the pharynx through the neck and into the chest. Passing behind the heart and between the lungs and then through an opening in the diaphragm, it reaches the abdomen, running into the next part of the alimentary canal, which is the stomach.

Stomach.—This part of the digestive tube is wider than the gullet and is eight or nine inches in length. Fig. 42 shows the form of the stomach both when empty and as it appears when full of food. The empty stomach is quite obviously only part of a continuous tube, the alimentary canal; but the full stomach forms a sort of bag or pouch which can accommodate a meal quite comfortably. After being swallowed, food remains in the stomach for a considerable time while the digestive process begins. The food is prevented from leaving the stomach too soon by a device which is also shown in Fig. 42. This figure shows an enlarged view of the lower portion of the stomach, where it becomes continuous with the small intestine. At the point where the two join, the alimentary canal is surrounded by a powerful ring of muscle. When the muscular ring is contracted it closes the alimentary canal at this point, rather as if a purse string had been drawn up around it, so that food is kept back in the stomach three, four or more hours, according to the nature of the meal which has been taken. Fats, for example, remain in the stomach for purposes of digestion sometimes as long as seven hours. When the muscular ring relaxes the partially digested food is able to pass on into the small intestine. This ring of

muscle is called the *pylorus*, which comes from the Greek for a gate-keeper, and the pylorus in the human body, is, in fact, a sort of gate-keeper for the stomach.

The interior of the stomach is lined by excreting or goblet cells (see Fig. 3) : cells which manufacture a liquid which escapes, by a small opening at one end of the cell, into the general cavity of the stomach. The resulting fluid produced by all the goblet cells of the stomach wall is

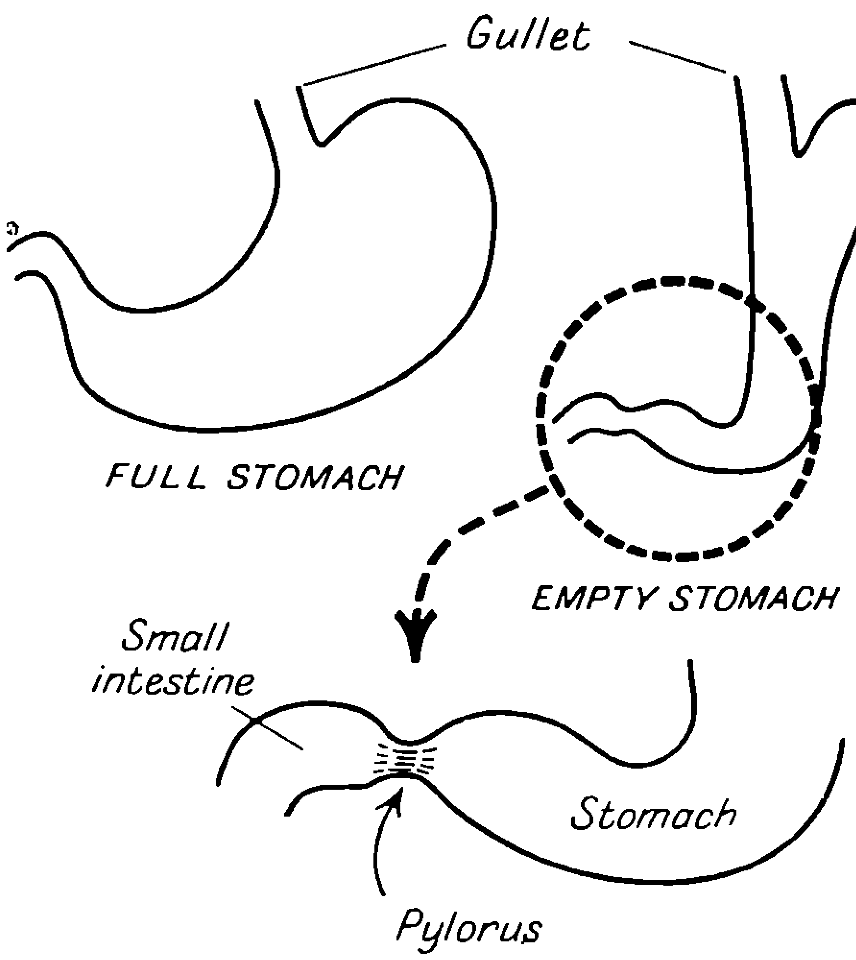


Fig. 42.—The stomach.

termed *stomach juice*. The stomach juice contains three principal ingredients. First, *mucus*, a somewhat slimy material designed to lubricate the food and facilitate its further passage along the alimentary canal. Mucus is also found in the *saliva* in the mouth and it is common experience that this liquid is slimy or slippery. The stomach juice also contains *hydrochloric acid* in a strength of about 0·2 per cent. This acid softens the fibres of meat and fleshy foods generally, thus aiding the digestion of these foods. The third ingredient, or rather ingredients, of the stomach juice are complex organic chemical substances known as *ferments*.

Fermentation generally suggests something turning bad, but there are, of course, good kinds of fermentation. That which takes place in the stomach is one of these. Most people will have noticed that when at any time they have been sick, the stomach contents that come up into the mouth have a sour taste as a result of this digestive fermentation.

Small Intestine.—Leaving the stomach, the food passes next into the small intestine, which is also lined by goblet cells producing another digestive liquid, the *intestinal juice.* This fluid contains mucus and ferments as before,

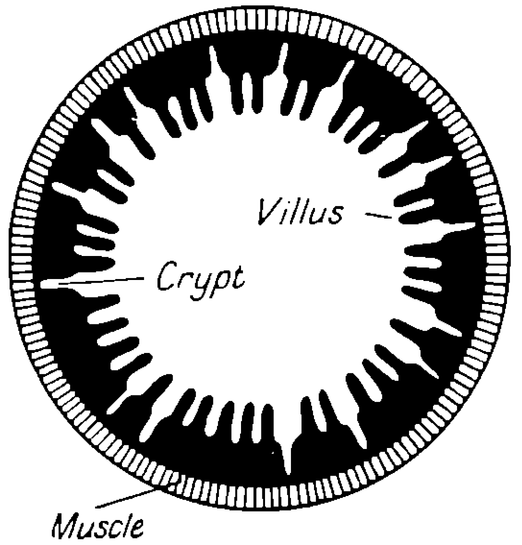


FIG. 43.—Diagrammatic section across the small intestine.

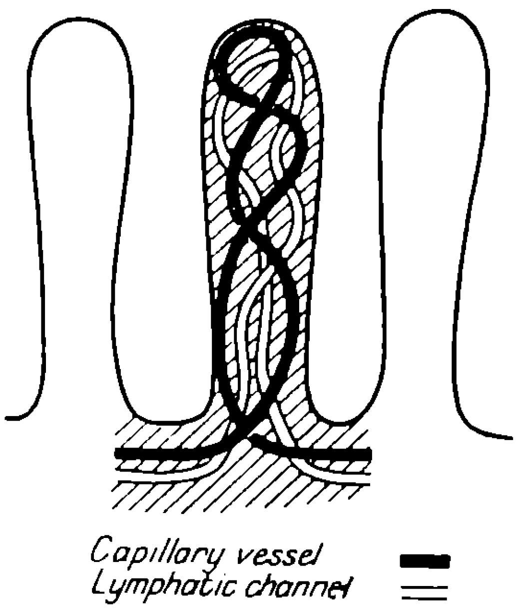


FIG. 44.—A villus.

and it also contains an alkali, bicarbonate of soda, which neutralizes the acid of the stomach juice. The interior of the small intestine feels somewhat velvety on account of the fact that its lining is not flat and smooth, but contains many millions of minute projections like microscopic fingers sticking up from its wall. Between these projections are little depressions (Fig. 43) which are termed *crypts.* The crypts are lined by goblet cells which produce the intestinal juice. The projections are called *villi* (singular, villus), and their purpose is to increase the internal surface area of the wall of the intestine so that there is more space available for digested food to soak through than if the intestine had a smooth lining.

Fig. 44 shows a single villus greatly enlarged. Like other parts of the body, it is a mass of protoplasmic cells,

and amongst these cells run a small capillary blood vessel and a small lymphatic channel, branches of larger vessels coursing in the wall of the small intestine. Between the liquefied, digested food inside the intestine and the capillary inside the villus, there is no barrier other than one or two minute cells. Consequently, the nutritious parts of the diet easily soak through these cells, and so enter the blood stream. This applies to all foods except fatty and oily foods. These latter soak into the lymphatic channel instead of into the blood. But since the lymph eventually enters the blood stream at a point in the neck (as explained in Chapter 5) all kinds of food finally get into the general circulation and so can be carried to the various cells of the body. The blood vessels running from the small intestine travel, for the most part, to the *liver*. The appearance of liver will be familiar from seeing animals' livers in butchers' shops and this organ, both in animals and in man, is made of cells which specialize in storing food brought to them by the blood from the small intestine. Some of the food is converted by the liver cells into glycogen, which is utilized by muscles, as explained in Chapter 4.

Large Intestine.—Since the food is digested and the nutritious parts of it absorbed in the small intestine, all that remains to enter the large intestine is an indigestible residue. As this residue travels along the large intestine, water is extracted from it and soaks into blood vessels in much the same way as food did in the small intestine.

Rectum.—Eventually, the more or less dried residue of the meal enters the last part of the large intestine which is the rectum, a dilated part of the alimentary canal, designed to accommodate the intestinal contents until such time as they can be evacuated from the body through an opening, the *anus*.

Notice that food is held up at two points on its journey through the alimentary canal. First, at the stomach, where the newly-eaten meal is delayed while digestion begins, and second, at the rectum, where the remains of the meal are delayed pending evacuation.

Appendix.—Fig. 40 illustrates a matter of some interest. At the point where the small intestine enters the large intestine, it will be seen that the food can go in two directions, either along the large intestine in the normal manner, or else into a little blind alley, the *cæcum*. In some animals, principally those which live upon plants, the cæcum is a large and important part of the alimentary canal in which these animals digest the woody, fibrous parts of the plants which they eat. In man, it is of little use, and has dwindled away to its present insignificance. From the lower end of the cæcum leads a still smaller passage, the *appendix*, which, when inflamed, gives rise to the condition known as *appendicitis*.

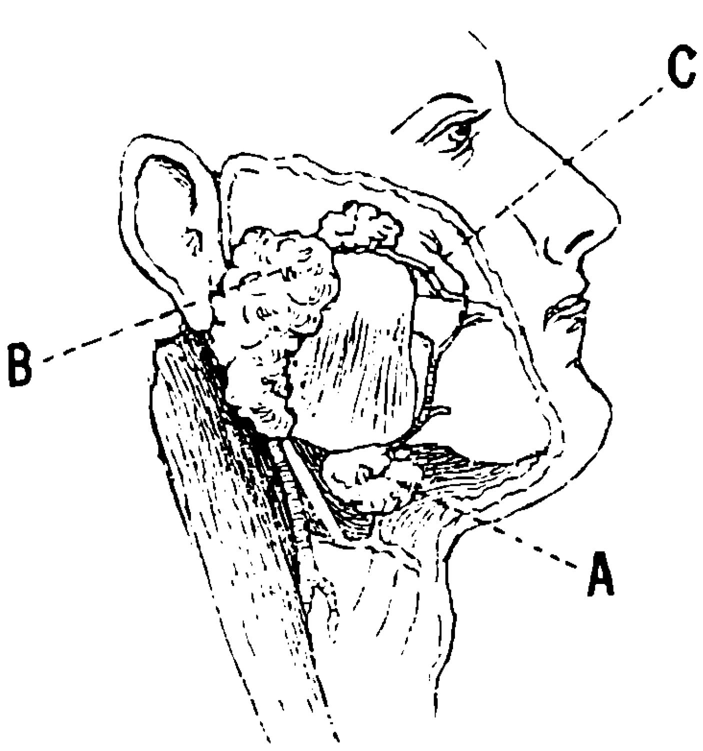


FIG. 45.—Dissection of the face to show salivary glands. A. Submaxillary gland. B. Parotid gland. C. Duct of parotid gland.

Glands. — The stomach and intestinal juices are not in themselves sufficient to digest all the different ingredients of a varied diet. Some additional digestive fluids are necessary and these are manufactured by groups of cells situated outside the alimentary canal, and are conveyed into the alimentary canal through a series of tubes or pipes. Such collections of cells are termed glands, this being the physiological name for any group of cells which manufacture a liquid. The one exception to this statement is the lymphatic gland, which does not manufacture a liquid at all, but merely acts as a filter on the course of the lymph channels. The lymphatic gland is badly named : indeed, American physiologists use the term lymphatic *node*, to avoid ambiguity. With this one exception, however, gland always means a collection of cells manufacturing some sort of liquid.

Salivary Glands.—The first of these extra digestive glands are the salivary glands (Fig. 45). These are fleshy masses of cells, embedded in the skin of the face, which manufacture the liquid known as *saliva.* This liquid is conveyed into the mouth (that is, into the alimentary canal) by a number of small tubes which are indicated in the figure. The saliva, like the stomach juice, contains mucus, and also a ferment. The process of digestion, therefore, begins in the mouth and food should be well chewed in order to mix it thoroughly with the saliva.

Pancreas.—Fig. 46 represents the stomach and part of the small intestine. Below, and somewhat behind the

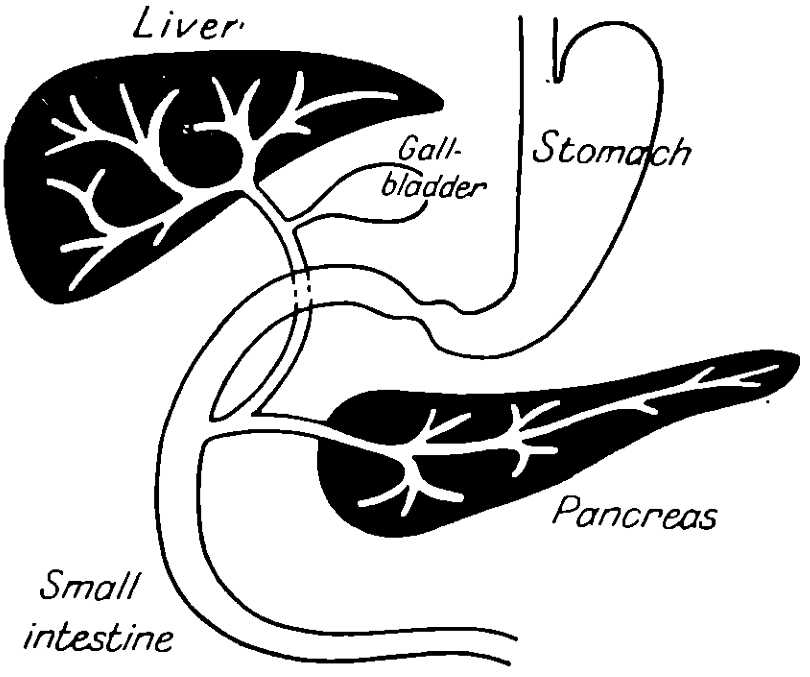


FIG. 46.—The liver and pancreas.

stomach, is another digestive gland. This is the *pancreas* or *sweetbread* (as it is called in animals), a collection of cells forming a fleshy mass about six inches in length and two inches in breadth. The cells of the pancreas manufacture a digestive liquid known as the *pancreatic juice,* and this liquid makes its way along small spaces between the cells until ultimately it leaves the organ by way of a tube (shown in the diagram) which conveys it into the small intestine.

Liver.—Above and to the right of the stomach (Fig. 46) is another digestive gland known as the *liver.* This organ is placed immediately behind the lower ribs on the right

side. It has already been described as a sort of storehouse for food which has been absorbed from the small intestine, but some of the liver cells, instead of storing food, manufacture a digestive juice which is known as the *bile*. The liver is therefore a digestive gland as well as a food-storing organ. The bile flows from the liver down a tube which is shown in the diagram, and eventually enters the small intestine at the same point as does the pancreatic juice. When there is no meal in process of digestion, the bile from the liver is side-tracked into a small bag or pouch, the *gall-bladder*. This is also shown in Fig. 46. When a meal is taken, the bile emerges from the gall-bladder and enters the small intestine.

Summary of Alimentary Canal.—The food enters the mouth, where it is tasted by the tongue, ground up by the teeth, and mixed with the saliva. It then passes into the pharynx, down the gullet, and so to the stomach. The action of the pylorus causes the food to be held up in the stomach for a number of hours while it is acted upon by the stomach juice. When the pylorus relaxes, the food passes into the small intestine. In the upper part of the small intestine, digestion is continued by the action of the intestinal juice, the pancreatic juice, and the bile from the liver. In the lower part of the small intestine, the nutritious elements of the diet are absorbed through the villi into the blood stream, with the exception of fats which pass into the lymph stream. As the non-nutritive residue travels along the large intestine, water is absorbed from it, the more or less dry remainder being stored in the rectum until it is evacuated from the body.

Constipation.—Before leaving the digestive system, it is necessary to consider the question of constipation, a term which means imperfect or infrequent evacuation of the contents of the rectum. In this connection, it should be noted that the word " bowel " is used by different people in different senses and sometimes causes confusion. To the physiologist, bowel is synonymous with intestine: small

bowel or small intestine ; large bowel or large intestine. Ordinary people are not, of course, familiar with the activities of any part of the intestine other than the last part, so that to them, the word bowel usually implies the rectum.

Normal bowel action.—It will be remembered that the alimentary canal moves its contents along by virtue of muscular activity. When the rectum exhibits this same muscular activity, it expels its contents, since there is no further portion of the alimentary canal into which the rectal contents can be passed. The musculature of the rectum contracts in response to four different kinds of stimulation, which are :—

1. stretching,
2. chemicals,
3. habit,
4. reflex action.

Whenever there is sufficient residue within the rectum, the muscles are stretched and so contract and expel the stored-up food residue. Certain chemical substances, like cascara, senna and castor oil, cause the rectal muscles to contract even when there is not much residue present. These chemicals are used as purgative drugs. The rectum also has a tendency to form the habit of contracting and expelling its contents (or at least desiring to do so) at certain hours of the day which vary from person to person. Finally, when a fresh meal enters the upper part of the alimentary canal, that is, the stomach, the rectum has a tendency to contract and expel the remains of the previous meal. This is a type of reflex action described in Chapter 9.

The normal action of the bowels is caused by :—

1. distention of the rectum,
2. reflex action after a meal,
3. habit,

but not, of course, by the action of drugs or chemicals which are only required when normal activity is not present.

Causes of constipation.—It follows that constipation occurs when something interferes with the factors responsible for normal bowel activity. The principal causes of constipation are :—

1. a naturally insensitive bowel,
2. lack of residue from the diet,
3. ignoring the desire to empty the rectum,
4. lack of proper habit formation.

Some people are born with a rectum which is not very sensitive to distention and, consequently, these individuals are more liable to constipation than others. Civilized people, as opposed to savages or animals, tend to live upon a diet which is so highly refined that there is relatively little residue to pass into the rectum and stimulate it. This, again, contributes to constipation. Some children, as a result of improper training, habitually ignore the desire to have their bowels moved, prefering to continue with some interesting occupation or pastime. When the rectum is slighted in this way, it presently gives over trying to work, and constipation supervenes. Again, as a result of bad training in childhood, some people never permit the rectum to form a regular habit of working and this is also a factor in the production of constipation.

Prevention of constipation.—Constipation may be prevented, and sometimes cured, by attention to three points. First, there should be in the diet a sufficiency of indigestible material to provide the necessary bulk for rectal stimulation. Such material is termed " roughage " and consists of food such as the green and fibrous parts of vegetables, the coarser parts and skins of fruits and the husk of grain which is present in brown bread (though absent from the more refined white bread). Water may serve a similar purpose if a sufficient quantity is taken. A certain amount is absorbed from the large intestine, but any excess over the body's needs passes on into the rectum and serves to distend that organ. A second point in the prevention of constipation is to teach children not to ignore the natural desire to

empty the rectum. Thirdly, it is wise to bring up a child to form the habit of having the bowels moved at a regular hour of the day, and if the time chosen is just after a meal, such as breakfast, the factor of reflex action is also combined with habit.

Effects of constipation.—Some people, mostly ill-informed, have asserted that constipation may lead to cancer, appendicitis, ulcers of the bowels, and other terrible diseases. There is no evidence whatever to support such a view and constipation in itself does not give rise to serious complaints. Nevertheless, constipation is a thing to be avoided because, obviously, no good purpose is served by carrying about in the alimentary canal an unnecessary weight of useless residue. The presence of unevacuated waste matter in the rectum and large intestine may, in some cases, give rise to a mild poisoning effect sufficient to cause a blotchy, sallow complexion and a general feeling of being below par in health. The weight of the accumulated alimentary contents may also, in certain cases, cause undesirable tension to be placed upon blood vessels and nerves which are attached to the alimentary canal.

CHAPTER 8

THE EXCRETION OF WASTE PRODUCTS

ALL living organisms give rise to waste products during the course of their activities. The process of getting rid of these waste products is termed excretion and has already been referred to in Chapter 2. It would not, however, be correct to speak of an excretory system in the case of man and the higher animals, since some of the organs concerned belong to systems concerned with processes other than excretion. The excretory organs are :—

1. Bowel (dietetic residue).
2. Lungs (carbon dioxide).
3. Kidneys (urine).
4. Skin (sweat).

The dietetic residue from the alimentary canal is not a true waste product. It is merely rejected, indigestible residue which has never been part of the body at all. Some true waste products, produced by the activities of the living cells of the body, are excreted by this route, however, and so the bowel must be included in the list of excretory organs.

The lungs, although part of the respiratory system, are also organs of excretion, since it is through them that the body gets rid of the important waste matter carbon dioxide. This process has been described in Chapter 6.

Kidneys and Urine.—The *urine* is a fluid consisting of about 96 per cent. water and 4 per cent. of solid waste matter dissolved in it. This liquid is produced by two organs known as the *kidneys* which are situated in the back part of the abdomen at about the level of the waist. The urine produced by the cells which form the kidney is

conveyed along a fleshy tube, the diameter of a thin pencil, to a muscular bag or pouch, the *bladder*, situated at the bottom of the trunk. This arrangement is shown in Fig. 47.

When examined under the microscope, each kidney is found to be composed of some thousands of minute, convoluted tubes. One of these is shown in Fig. 48. Such a kidney tube begins near the convex margin of the kidney in a sort of cul-de-sac and then winds a tortuous course

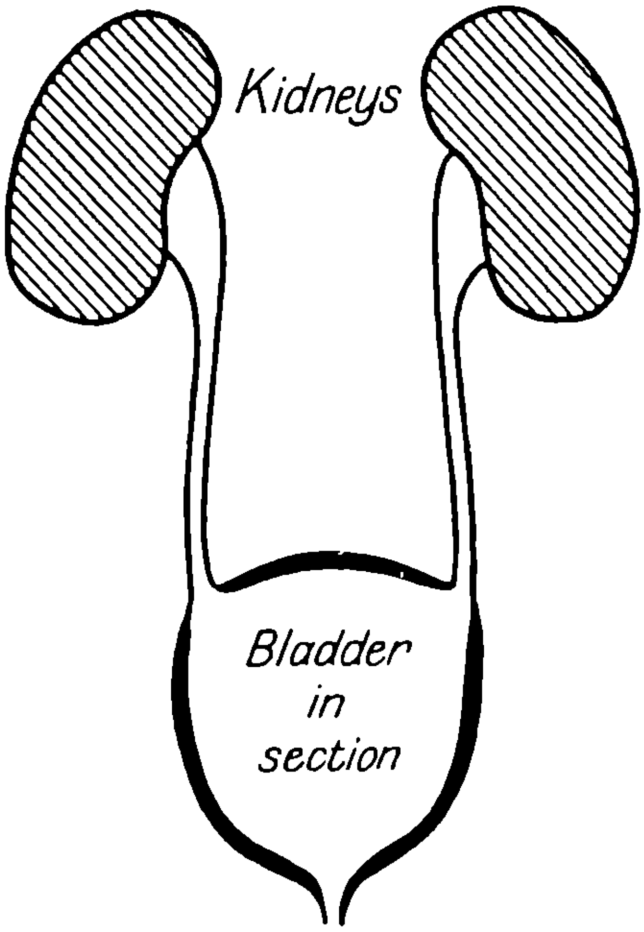


FIG. 47.—The kidneys and bladder

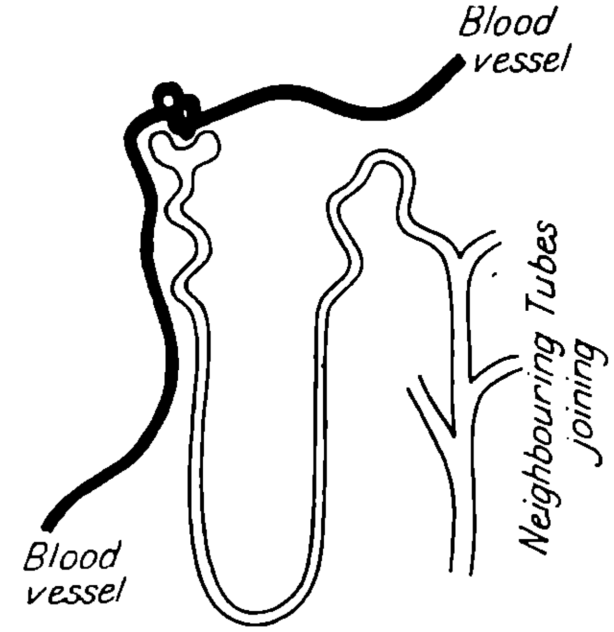


FIG. 48.—A kidney tube.

through the substance of the organ to the concave border. The kidney contains capillaries, like other parts of the body, and these form a series of loops and coils at the point where each of the little tubes begins. At this point there is no barrier between the blood within the capillary and the space within the kidney tube except the thin walls of the capillary and the tube. These walls, of microscopic thickness, easily allow water and waste products from the blood to filter into the tube, thus forming the urine. Each of these little tubes finally delivers its urinary contents to the main drainage tube of the kidney, which leads to the bladder, as has

already been described. The urine is retained in the bladder until it is evacuated from the body.

The Skin.—The skin produces an excretory liquid, the *sweat*, which is somewhat like urine in composition. The skin and the kidneys are in a sense complementary to each other, since when sweating is marked (as during hot weather) the production of urine is relatively scanty and vice versa.

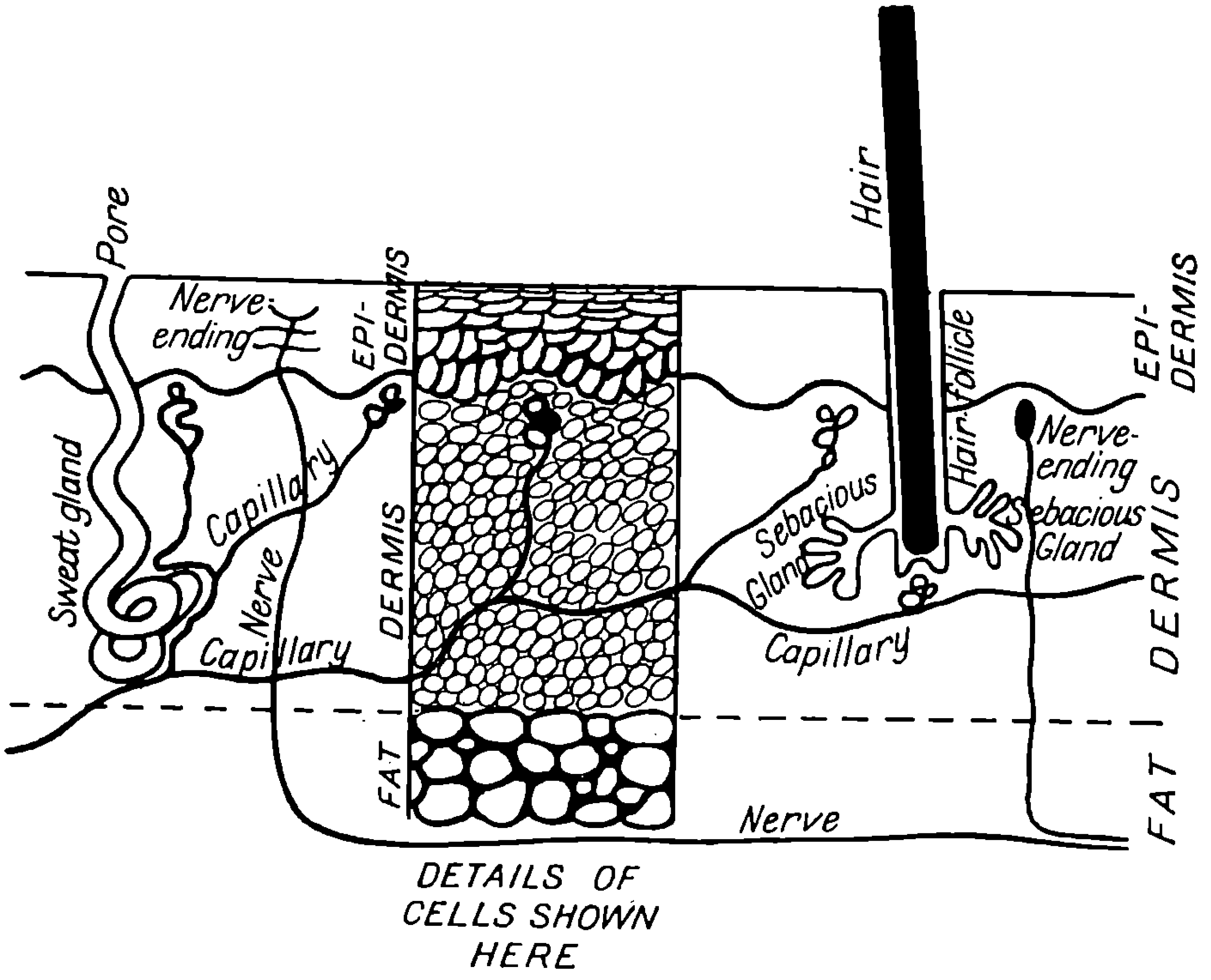


FIG. 49.—The skin in section (diagrammatic).

Excretion is not the only function of the skin, however, this organ having several tasks to perform, which are :—

1. Protection.
2. Temperature regulation (sweat and fat).
3. Excretion (sweat).
4. Appreciation of sensation (nerve endings).

These functions will be better understood by referring to Fig. 49, which shows the structure of the skin. This figure represents, in diagrammatic form, a sectional view

of the skin, showing the various layers of which it is composed.

Epidermis.—The outermost layer consists of flattened, dead cells, which are somewhat hard and horny, and in some animals form definite scales. This is the protective layer of the skin and is known as the *epidermis*, false, or scarf skin. The deeper layers of the skin are formed of ordinary living cells, but as these divide and multiply they tend to be pushed up towards the surface where they die and so form the protective outer layer. Since the cells of the epidermis are not living they do not require a blood supply and so no blood vessels run in this layer of the skin. For this reason, it is possible to make a slight superficial scratch upon the body which does not bleed. As the wear and tear of everyday life wears away the epidermis, it is replenished by cells from below.

Dermis.—The second layer is the true skin or *dermis*, which meets the epidermis in an irregular line of junction. This junction is the region where the cells are most active in multiplying and so the blood supply here is particularly plentiful, as can be seen in the diagram. The dermis, or living skin, also contains nerves (a few of them actually penetrate to the epidermis) by means of which the body experiences sensations of touch, pressure, pain, heat and cold. For this reason, the skin is often described as a sense organ. Nerve endings are more fully explained in Chapter 9.

The fat.—Below the skin is a layer of fat which is, of course, a food store for the body. Fat is a poor conductor of heat, and so the fatty overcoat, worn beneath the skin, keeps inside the body the heat which is largely produced by the contraction of muscles.

Sweat.—In the surface of the skin are a large number of openings, the *pores*. These are the ends of minute tubes which wind their way down through the epidermis to end in a series of coils and loops in the deeper parts of the dermis. These tubes are the *sweat glands*. Capillaries are wound round the coiled part of a sweat gland, giving an

arrangement very similar to that seen in the kidney. Here, again, filtration occurs and a watery fluid percolates from the blood into the sweat gland, to emerge upon the surface of the body as the sweat. The sweat is not only an excretory liquid, but plays a part in regulating the temperature of the body. During vigorous exercise, when too much heat is being produced, the evaporation of sweat from the skin helps to cool down the body to its normal temperature. It should be borne in mind, however, that it is possible to catch a chill if this cooling effect takes place too rapidly. Therefore, after taking exercise, it is unwise to stand about in a draught, lest the drying off of the sweat lower the temperature too much.

Hair.—Lower animals, since they do not clothe themselves artificially, frequently have a natural covering of hair to keep them warm. Some remains of the hairy covering persists in human beings : sparsely over most of the body, but plentifully upon the head. Each hair grows out of a socket which is known as a *hair follicle* and which penetrates through the epidermis into the dermis. The root of the hair consists of living cells which divide and multiply and so are pushed along the hair follicle nearer and nearer to the surface of the skin. These cells die as they get further from their blood supply at the hair-root, and so the part of the hair which projects from the surface of the body is nothing more than a column of dead cells which have become tough and horny.

Sebum.—Connected with the deeper parts of the hair follicle are one or more sets of minute tubes. These tubes are lined by cells which manufacture a waxy or oily substance known as *sebum*. The tubes themselves are termed *sebaceous glands*. Sebum is the natural lubricant of the skin, serving to keep the hairs pliable and the surface of the epidermis reasonably soft. In those parts of the body where there are no hairs, the sebaceous glands open directly upon the surface of the skin.

General function of the skin.—The importance of the skin should be clearly recognized. It is the barrier between the

community of cells which form the body and the external environment. Through it these cells excrete some of their waste products and make contact (by means of nerve endings) with the outside world. The correct functioning of the skin ensures that the interior of the body shall remain at a constant temperature irrespective of the temperature outside. This independence of the temperature of the environment has enabled the warm-blooded animals to spread to all parts of the world from the tropics to the poles. Cold-blooded animals have no fatty layer beneath the skin, and consequently their temperature varies with their surroundings. In warm weather and in warm parts of the world, they can live satisfactorily. In cold weather, their vital processes become slower and slower and eventually reach a very low ebb, so that most cold-blooded animals have to hibernate, that is, to go to sleep for the winter. Man, unique amongst the animals, has carried his independence still further by covering his body with the furry skins of other beasts and by manufacturing artificial covering fabrics.

CHAPTER 9

THE NERVOUS SYSTEM

So far the various systems of the body have been described separately, but in real life they do not work independently of one another. For example, when the muscles are performing vigorous labour, the circulatory system has to give them a better blood supply, while the respiratory system ensures a more rapid exchange of oxygen and carbon dioxide between the blood and the outside air. This co-ordination of the body's activities is brought about by what is in effect the master system of all, the *nervous system.* The nervous system is made up of cells which are specialists in conduction, a process which will be best understood by referring once more to the amœba, and then tracing something of the evolution of the nervous system in more and more complicated creatures until we arrive at man himself.

Conduction.—Look again at Fig. 1, which represents an amœba and shows the way in which it moves. In Chapter 2, it was explained that the amœba could be made to move to the right if a drop of vinegar was placed on the left of the creature. Since movement occurs on the side of the cell which is remote from the irritation or stimulation, it follows that some sort of sensation or impulse has been conducted through the protoplasm of the organism. The exact nature of this sensation is not clearly understood.

Nerve Cells.—Fig. 50 represents an imaginary creature a little higher up the scale of living things than the amœba : a creature consisting of perhaps half a dozen cells of similar appearance and all adhering together. If a drop of

vinegar were placed at the left side of such a creature, it would move away to the right as did the amœba, because the sensation would have been conducted through the protoplasm of all the cells from left to right. This is indicated by dotted lines in the figure, which show the possible pathways which the sensation could take. Although conduction takes place rapidly through the protoplasm of a single cell, there is a certain amount of delay in passing on the impulse from one cell to another : the cell boundary apparently offering some obstruction. The process may be compared to a line of people passing some object from hand to hand, each individual receiving the object from his neighbour and quickly swinging his hand from one side to

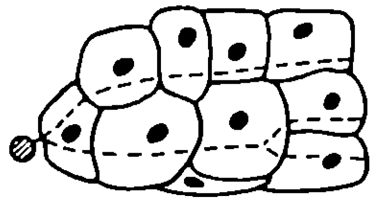


FIG. 50.—Conduction through several cells.

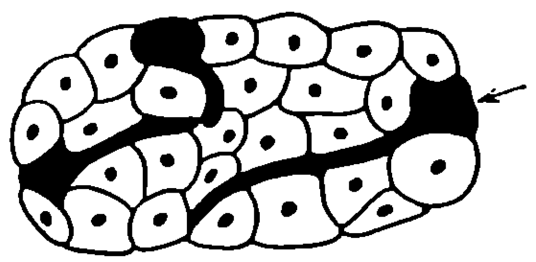


FIG. 51.—Simple nerve cells.

the other. As he hands the object to the next person in the chain there is perhaps a certain amount of delay and fumbling, while this next individual takes hold of it. The delay at the cell boundary is, of course, very slight, and in the case of a creature composed of only a few cells, it is not important. If this arrangement obtained in man, who is made of millions of cells, then the slight delay multiplied a million times, would represent a considerable period of time. Thus, if a man stood upon an upturned drawing pin, it might well be an hour before the sensation of pain reached his brain at the other end of his body, which would be extremely inconvenient.

Fig. 51 shows Nature's device for overcoming the difficulty. In a creature composed of an unwieldy number of cells, some of the cells (black in the figure) are drawn out to a considerable length, having long, protoplasmic tails which

reach for a considerable distance across the animal. These are conducting, or *nerve cells*, in their simplest form. Now, suppose that a drop of vinegar (or any other source of sensation) is placed at one side of the creature, quite near to one of the nerve cells. The impulse travels in the protoplasm of the nerve cell, perhaps to the other side of the animal, without needing to cross intervening cell boundaries, since the one cell extends from one side to the other. This prevents the delay which has previously been described and speeds up the response of the organism to external stimulation. An animal which possesses nerve cells is thus able to move away rapidly from irritation and danger, or to move quickly towards food, and is thus a more efficient animal than one without specialized conducting cells.

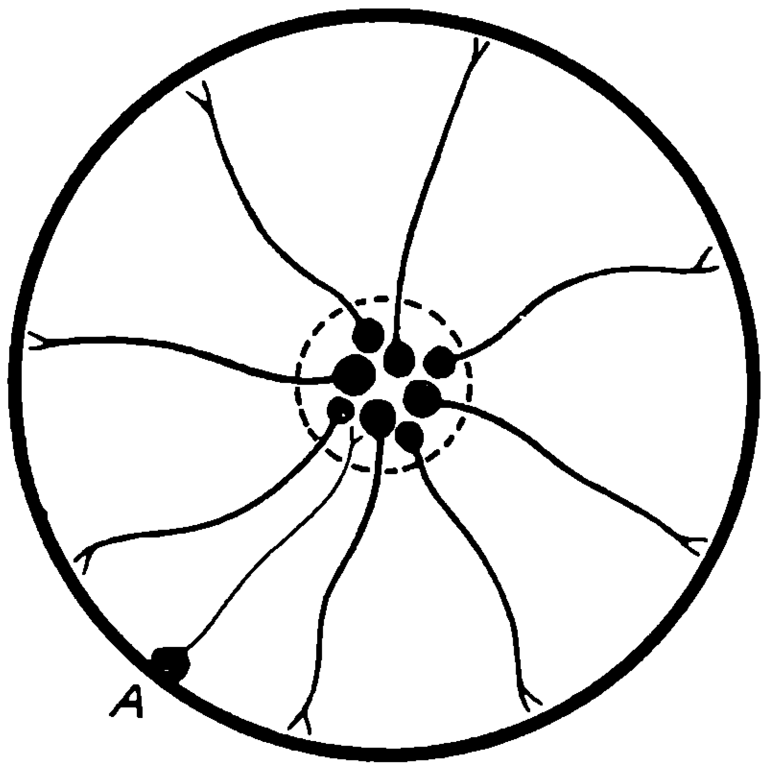


FIG. 52.—A simple animal with a nerve centre.

Nerve Centres.—The nerve cells just described were arranged indiscriminately amongst the general mass of cells forming the complete animal. Higher up the scale of life, it is usual to find nerve cells arranged in a more orderly manner, many grouped together in one part of the body, which may then be termed a *nerve centre.* From the nerve centre the protoplasmic tails of the nerve cells extend to all parts of the creature. Fig. 52 shows this arrangement. Any event occurring at one point on the body surface sets up a sensation which is conveyed by a nerve cell to the nerve centre. Here it is transmitted to all the other nerve cells and by them to all parts of the body. The animal is therefore able to respond to stimulation as a co-ordinated

whole. The nerve centre may be compared to a telephone exchange in a factory or business house. The head of the works receives information from a subordinate in one or other department and can immediately transmit instructions to all the departments under his control. It is, indeed, a common figure of speech to refer to the office of a governor or director as the "nerve centre" of the business or institution.

Nervous System.—A single nerve centre may be quite sufficient for the activities of a relatively simple organism, but the larger and more complicated animals require many nerve centres to control the activities of the various regions or segments of the body. Fig. 53 represents, in a very

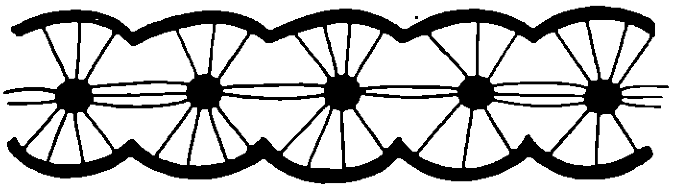


FIG. 53.—The nervous system of the earthworm.

diagrammatic manner, a portion of an earthworm seen in section. This animal is composed of many segments, clearly indicated on the outside of its body by ring-like markings. Each ring or segment is very much the same as its neighbours and it is possible for an earthworm to be divided into two portions, each of which survives as a separate animal. This is because each segment has its own nerve centre and so is a semi-complete creature. In the ordinary way, the segments do not lead an independent existence, since each nerve centre is joined to those on either side of it by the filamentous tails of some of its nerve cells. Consequently sensations, or *nerve impulses* as we may now call them, are not confined to one nerve centre and one segment, but can travel throughout the whole length of the worm. This is rather like the ordinary telephone system where subscribers are connected to an exchange, while the

exchange itself is connected by trunk lines to other exchanges in other districts.

The Brain.—Since the earthworm cannot move in two directions at the same time, one end has to take the lead in deciding which way the animal is to travel. This predominating end is termed the *head*. The head is that portion of an animal which first enters a new environment, and so is the first to come into contact with danger or food.

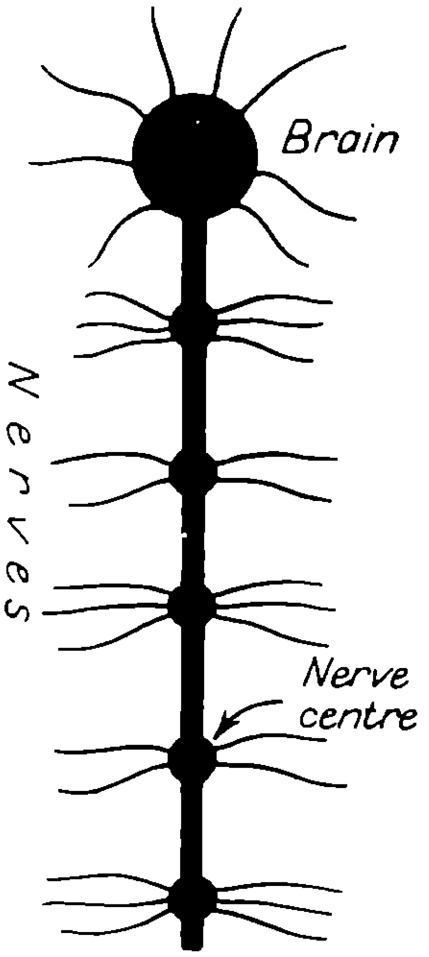


FIG. 54.—Brain and nervous system.

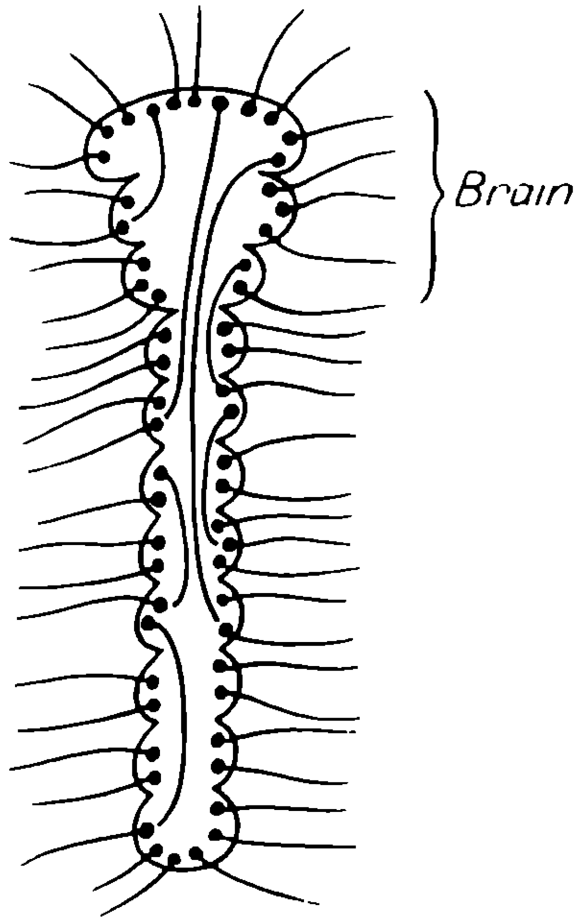


FIG. 55.—A complex brain and nervous system.

In the case of the worm, it is the head which first emerges from a hole in the ground and decides whether it is safe for the rest of the body to follow, or whether the early bird is waiting, necessitating instant retirement. Thus the head of an animal is the most important segment and consequently the nerve centre belonging to this segment is the most important nerve centre, exercising control over all the others. Such a nerve centre is termed a *brain*, and is usually larger, as well as more important, than any other nerve centre in the body.

Fig. 54 shows the nervous system of a somewhat higher animal. Each section of the body has its nerve centre, as in the case of the worm. The nerve centres are connected with one another, and the topmost centre, larger than any other, is the brain.

Fig. 55 represents the nervous system of man, or one of the higher animals. Some of the individual nerve cells are indicated, each with its long, protoplasmic tail extending from a nerve centre to some distant part of the body. The life of a higher animal is much more complex than that of the earthworm and this necessitates a more complex brain. Instead of one large nerve centre forming the brain, in this case the first three are enlarged and, predominating over all the others, form the brain.

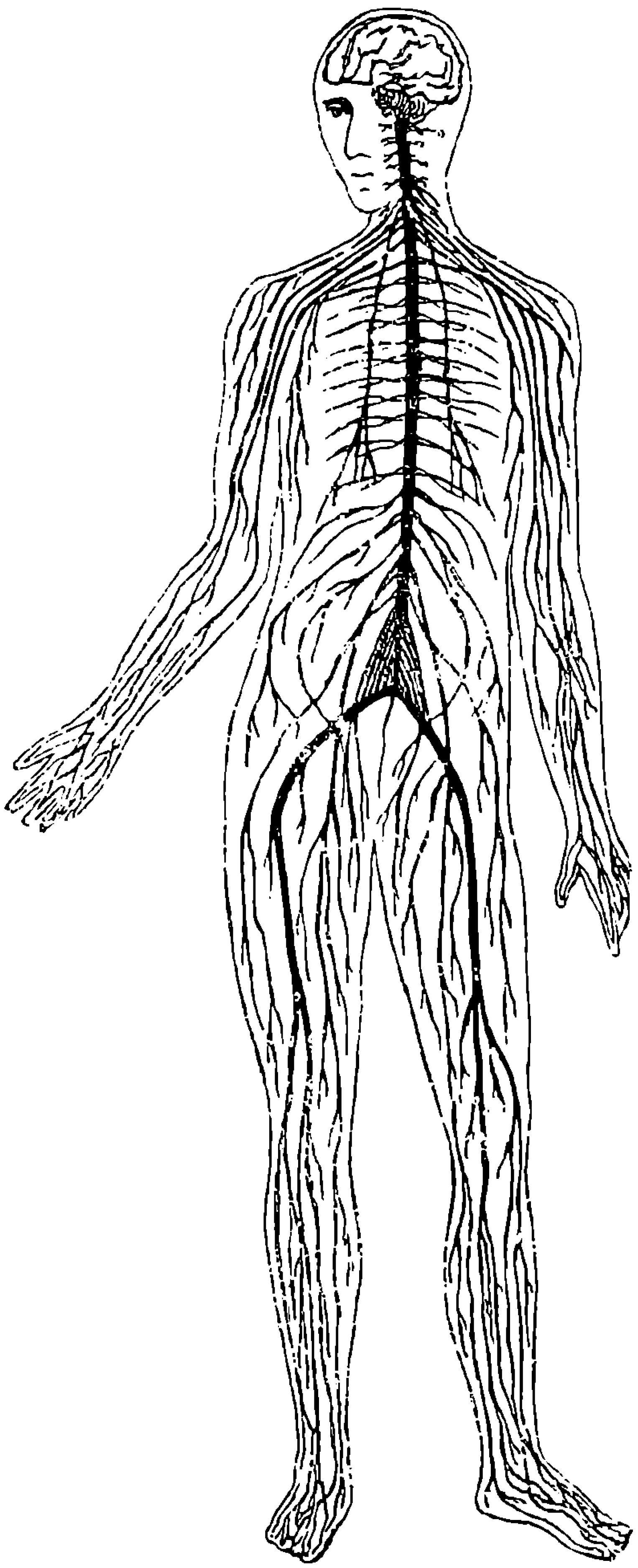


Fig. 56.—The human nervous system in relation to the body.

The body of man is not so clearly divided into segments as is the body of the worm, but in the region of the chest the alternation of ribs and spaces gives some indication of segmental arrangement.

Similarly, the nerve centres of man (apart from those forming the brain) are not sharply demarcated from one another, but each blends imperceptibly with its neighbours above and below. It can be seen from the figure how a nerve cell in the brain may send its long tail down the nervous system until it establishes contact with a nerve cell in a lower centre, thus enabling the brain to control the activities of such a lower nerve cell.

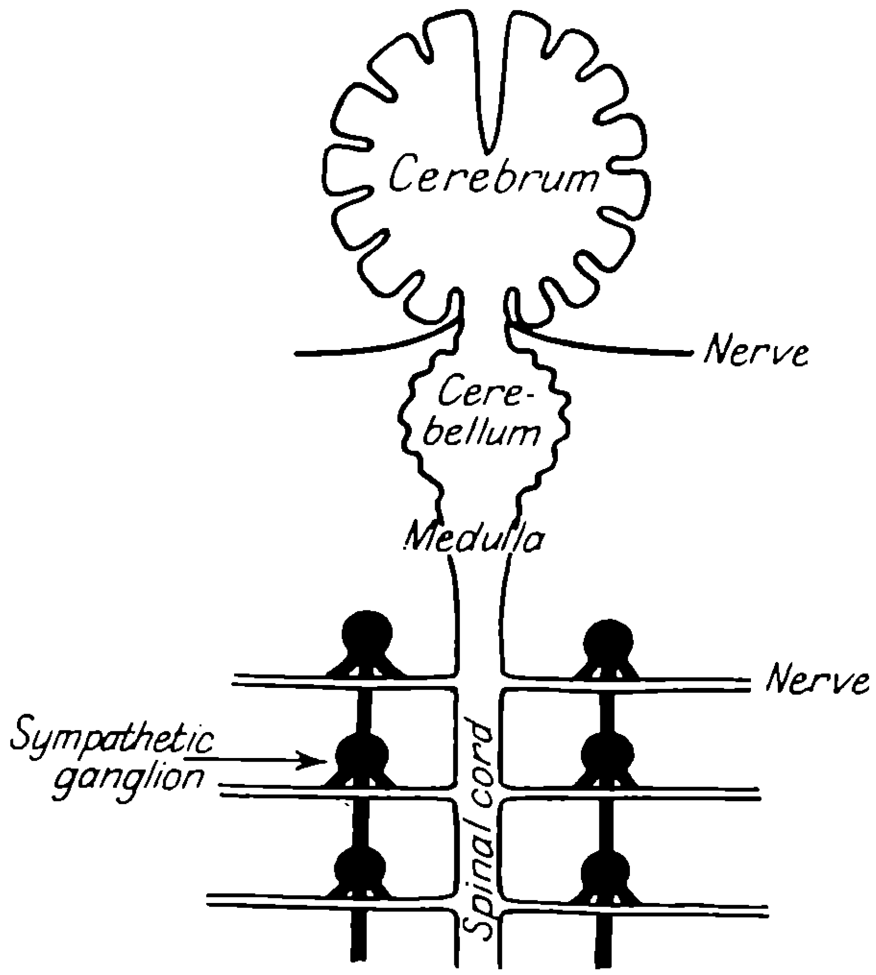


FIG. 57.—Diagram of the human nervous system.

The Human Nervous System.—The foregoing description has been reduced to very simple terms for the sake of clearness. It now becomes necessary to consider the build of the human nervous system in more detail. Fig. 56 shows the general arrangement of the nervous system within the body, and Fig. 57 shows it in diagrammatic form. Frequent reference to these two figures will assist in understanding the following description.

Cerebrum.—Most of the space within the cranium is occupied by a large nerve centre which is termed the *cerebrum* (Fig. 58). A cleft in the mid-line, running from

before backwards, partly divides the cerebrum into two, incomplete halves, and this is indicated in Fig. 57. The cerebrum, being the nerve centre for the head, controls the movements of the face, the eyes, the tongue, etc. It also exercises control over all the other nerve centres and so co-ordinates the working of the body. The cerebrum is intimately associated with the exercise of the higher mental faculties, such as conscious thought, memory, and the initiation of voluntary movements. If this important nerve centre is put out of action (as by an anæsthetic) the ordinary conscious life of the individual temporarily disappears.

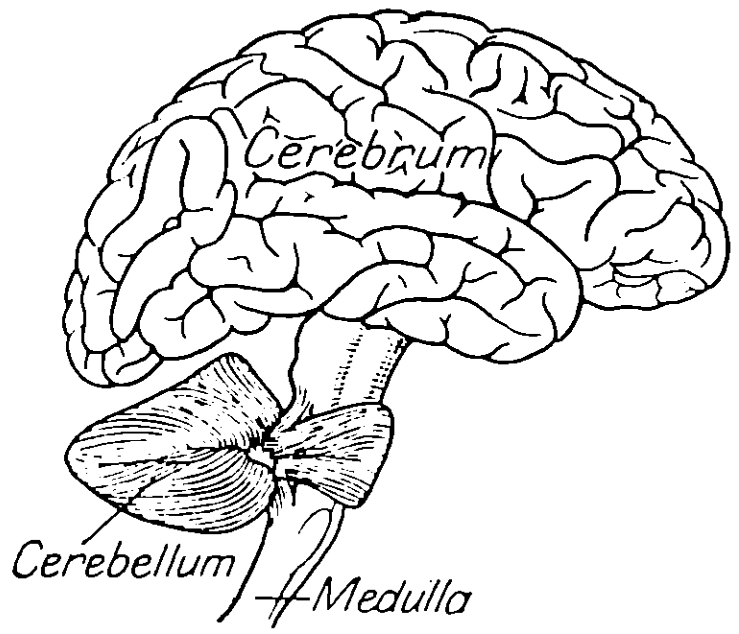


FIG. 58.—The brain seen from the right.

Cerebellum.—Below the cerebrum, and also contained within the cranium, is a smaller nerve centre called the *cerebellum* (Figs. 57 and 58). This part of the brain is chiefly concerned with maintaining the balance of the body. If the body has a tendency to fall towards the right, the nerve cells of the cerebellum send out messages to muscles on the left, telling them to contract a little and pull the body back into an upright position. The activities of the cerebellum are not normally represented in consciousness.

Medulla.—The third nerve centre of the brain is the medulla (Figs. 57 and 58). This is concerned with some of the primitive vital processes of the body, such as control of the heart beat.

Spinal Cord.—These three nerve centres of the brain completely fill the cranium and the rest of the nervous system lies outside the skull, the successive nerve centres forming the spinal cord. There is a hole in the base of the skull where the medulla and spinal cord meet and blend with one another. The spinal cord lies in the bony tunnel formed by the arches of the vertebræ, as was explained in Chapter 3. It is thus protected by bone in the same way as is the brain. The portion of spinal cord opposite to each of the vertebral bodies is generally regarded as a nerve centre, but, as already mentioned, there is no clear-cut division between one nerve centre and the next. The protoplasmic tails of the nerve cells emerging from each centre of the spinal cord are collected together in a bundle called a *nerve*. A nerve is therefore like an electric cable containing many individual wires.

Sympathetic Ganglia.—On each side of the spinal cord (but outside the bony tunnel of the vertebral column) lie other nerve centres which are called *ganglia* (singular: ganglion, from a Greek word meaning a knot). The two chains of ganglia, left and right, are termed the *sympathetic chains*. These additional nerve centres will be best understood if they are looked upon simply as detached portions of the corresponding centre in the spinal cord. They communicate with each other, and with the spinal cord, by means of nerve fibres, and some of their nerve cells send their protoplasmic tails into the nerves which run from the spinal cord to all parts of the body. Apart from the brain, therefore, each section of the human body is controlled by a nerve centre which is in three pieces, one in the spinal cord and two extra portions outside.

Neurones.—So far we have been considering the gross structure of the nervous system, but we must now examine the microscopic cells of which it is composed. Broadly speaking, three types of nerve cell are found in the human nervous system, and these are shown in Fig. 59. Each nerve cell consists of a blob of protoplasm, with a nucleus in the centre, just like any other cell, but in addition nerve

cells have a number of filamentous, protoplasmic processes extending from them. In the past there has been a certain amount of confusion as to what was meant by the term "nerve cell." Some physiologists used this term to mean both the solid mass of protoplasm and the various tails all considered together. This was undoubtedly correct, since all this protoplasm is part of one cell. Other physiologists, however, restricted the term nerve cell to the main mass of

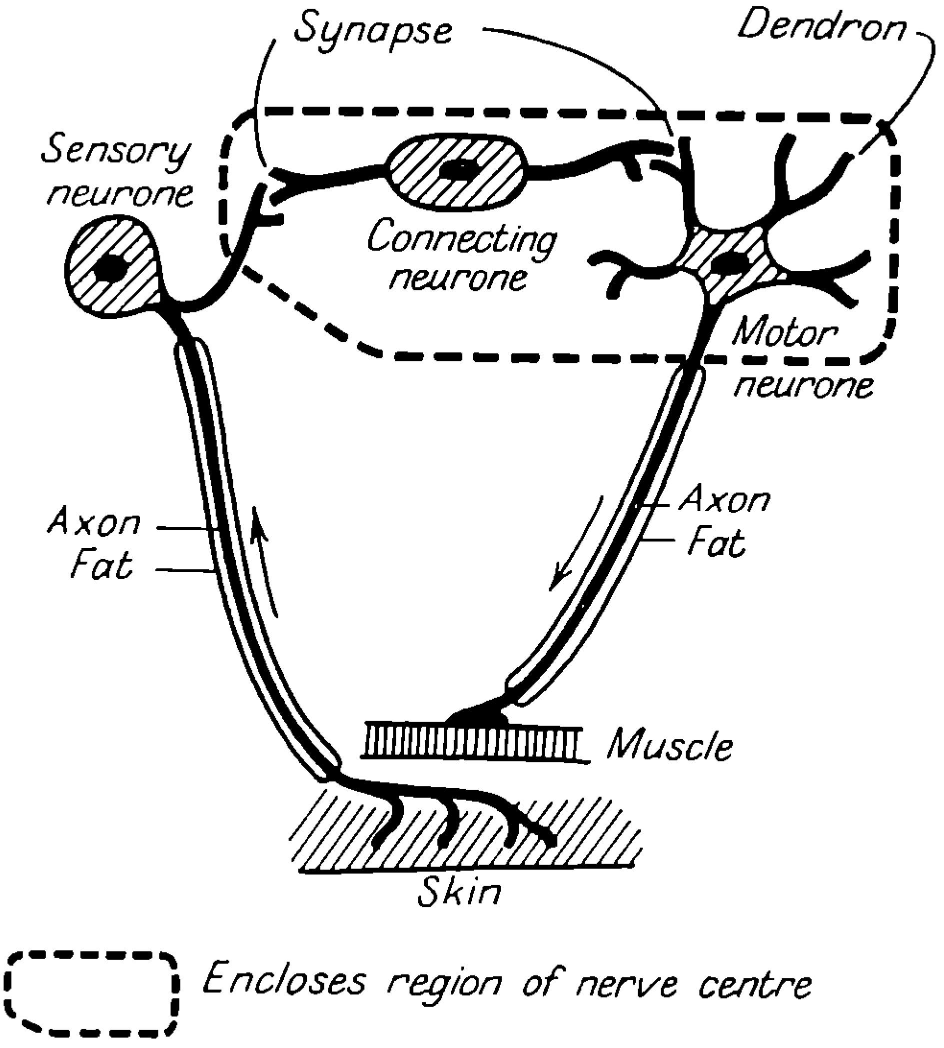


FIG. 59.—Neurones.

protoplasm, and spoke of the tails or fibres as if they were quite separate things. To avoid confusion the word *neurone* was introduced. This word means all the protoplasm, filaments included, which forms part of a nerve cell: in fact, the whole cell. When the main mass of protoplasm, which contains the nucleus, is referred to, the term cell-body is usually employed. The different types of neurone shown in Fig. 59 will now be described in detail.

Motor Neurone.—On the right of the figure a somewhat star-shaped cell is shown. From the angles of the

cell-body extend processes or tails of protoplasm which, with one exception, are fairly short. These are known as *dendrons.* The exceptional one is much longer, sometimes several feet in length, and is known as the *axon* of the neurone. The cell-body and dendrons are usually found within a nerve centre in the brain, the spinal cord or a sympathetic ganglion. The axon extends from the nerve centre to some distant part of the body, usually terminating in a gland, or in a muscle. From the cell-body nerve impulses travel along the axon and tell the gland when to secrete or the muscle when to contract. Since neurones of this type cause work to be done in some part of the body and movements to be effected, they are usually known as *motor neurones.* The axon of a motor neurone does not travel through the body by itself but is bound up in a bundle with many other similar axons, the whole forming a *nerve.* In order to prevent the impulses travelling along an axon from affecting its neighbours in the nerve, each axon is insulated by a layer of fat as indicated in Fig. 59.

Sensory Neurone.—The type of neurone shown on the left of the figure is called a *sensory neurone*, because it is concerned with conveying sensations from different parts of the body to the nerve centres. Like the motor neurone, it has an axon, insulated by a layer of fat. This axon begins in such a situation as the skin and travels in a nerve with other axons (both motor and sensory) until it reaches its cell-body. The cell-body of the sensory neurone is generally spherical in shape, and in the case of the spinal cord, it often lies just outside the nerve centre instead of inside it. This type of neurone has only one dendron.

Connecting Neurone.—In most of the nerve centres the sensory and motor neurones are linked together by means of connecting neurones. These usually consist of a somewhat oval cell-body with two dendrons, one at each end. The linking together of the different neurones is shown in Fig. 59, the dotted line indicating that all things inside it are within a nerve centre, while the arrows show the direction in which the nerve impulses travel. If some sensation,

for example, a painful one, affects the skin near the end of the sensory neurone's axon, a nerve impulse will travel to the nerve centre, along the various cell-bodies and dendrons to the motor neurone, giving rise to a motor impulse which may perhaps cause a muscle to contract. The resulting movement would usually serve to move that portion of the skin out of harm's way.

Synapses.—The place where the dendrons of two neurones come into contact with one another is called a *synapse* (Greek : in contact). It will be remembered that although conduction takes place very rapidly within the protoplasm of a single cell, there is always a certain amount of delay when an impulse has to pass from one cell to another. The synapses of the nervous system are places where nerve impulses pass from one cell to its neighbour and these are the points where nerve conduction suffers a slight delay : the synapse offering some resistance to the passage of the nerve message. Some drugs, such as alcohol, increase this resistance and so interfere considerably with the working of the nervous system. This is referred to in more detail in Chapter 14.

Grey and White Matter.—Although nerve cells or neurones are of microscopic dimensions, they form a visible mass when gathered together in large numbers. Seen in the mass the cell-bodies have a grey appearance and consequently those parts of the nervous system where cell-bodies abound are spoken of as grey matter. Axons, because of the fat surrounding them, have a somewhat white appearance when seen in large numbers and so those parts of the nervous system where there are many axons are referred to as white matter.

Fig. 60 represents the cerebrum in section as viewed from the front. The black area is grey matter, that is, the region where there are many cell-bodies. Notice that the grey matter is round the edge of the cerebrum, while the white matter formed by the axons belonging to these cell-bodies is in the centre. The more complex the life of an animal becomes, the more nerve cells does it require in its cerebrum.

Since Nature prefers to place these nerve cells near the surface of the brain, it follows that the higher animals require more brain surface than the lower. In order to obtain more available space, the surface of the cerebrum is thrown into folds or wrinkles, as indicated in the figure. The higher the animal the more wrinkly is its cerebrum, and man's is the most wrinkled of all.

Fig. 61 represents the spinal cord as it would appear if cut across and viewed from above. The grey matter (that is, the cell-bodies) is in the middle in this case, arranged in a pattern which roughly resembles the letter H. The white

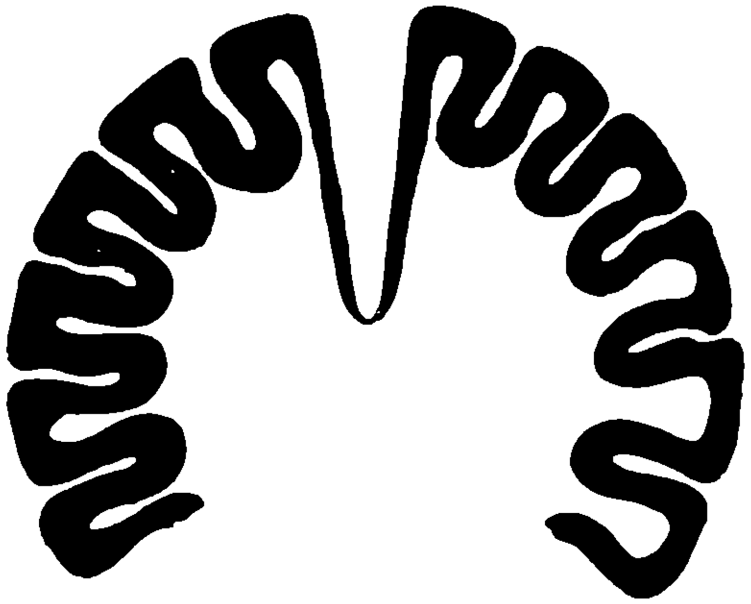


FIG. 60.—Grey and white matter in the cerebrum.

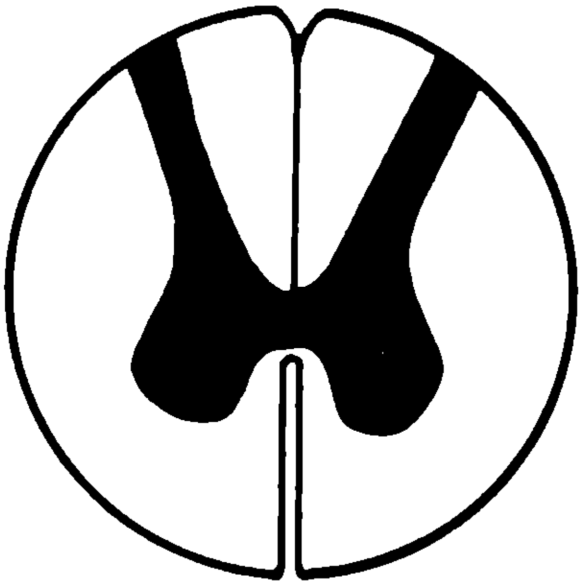


FIG. 61. Grey and white matter in the spinal cord.

matter is disposed round the grey. Like the cerebrum, the spinal cord is partly divided into two halves by deep clefts in front and behind as the diagram shows.

It is important to realize that the diagram of the cerebrum is a section viewed from in front. The diagram of the spinal cord, however, is a section viewed from on top. Although these sections are in different planes, they are combined in Figs. 62 and 64 for the purpose of simplification. In these figures, too, the grey matter of the spinal cord is outlined but is not shaded.

Reflex Action.—Fig. 62 shows three neurones at one particular level of the spinal cord, that is, they are in a single nerve centre. The axon of the sensory neurone

terminates in the skin, perhaps of the hand. The axon of the motor neurone terminates, we will suppose, in one of the muscles which produces movement of the hand. If a pin is stuck into the skin of the hand, a sensation is conveyed by the sensory neurone to this nerve centre. Here it is transmitted along the connecting neurone to the motor neurone, giving rise to an impulse which leads to the contraction of the muscle. The contraction of the muscle would cause the hand to be quickly jerked away from the pin. This is an instance of a nerve centre looking after the

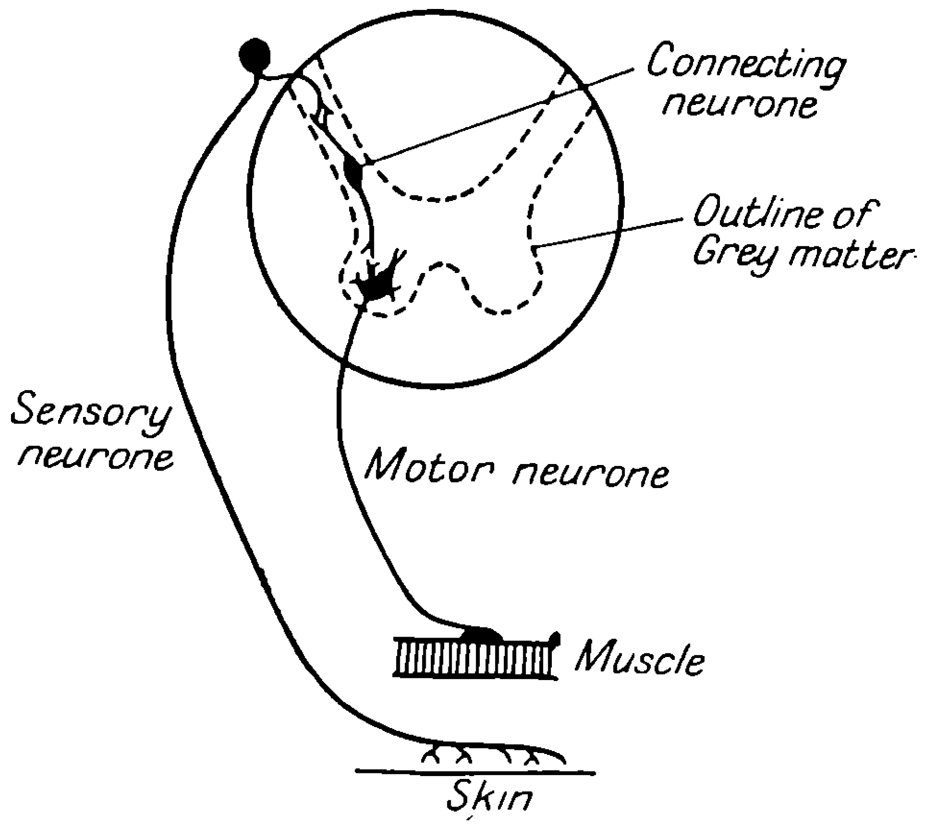


FIG. 62.—Spinal reflex action.

welfare of one particular region of the body, and this type of nervous behaviour is called *reflex action*, because the nerve impulse comes to the nerve centre and is, as it were, reflected away again. Any nerve centre is capable of reflex action, the brain equally with the spinal cord. Reflex actions are usually (not always) of a protective nature, and are carried out without reference to consciousness. As a rule more than one muscle contracts because the sensory neurone communicates, through connecting neurones, with motor neurones at several, adjacent layers of the spinal cord. This is indicated in Fig. 63, which represents a vertical section of the cord.

Conscious Nervous Activity.—Although reflex action in the spinal cord may protect you from pin-pricks, you are nevertheless quite conscious of the fact that a pin has penetrated the skin. It follows, therefore, that some information has been sent to the cerebrum. Fig. 64 shows the way in which the cerebrum is connected with any given level of the spinal cord. An incoming sensory neurone comes into contact not only with a connecting neurone, but also with the axon of another sensory neurone, the cell-

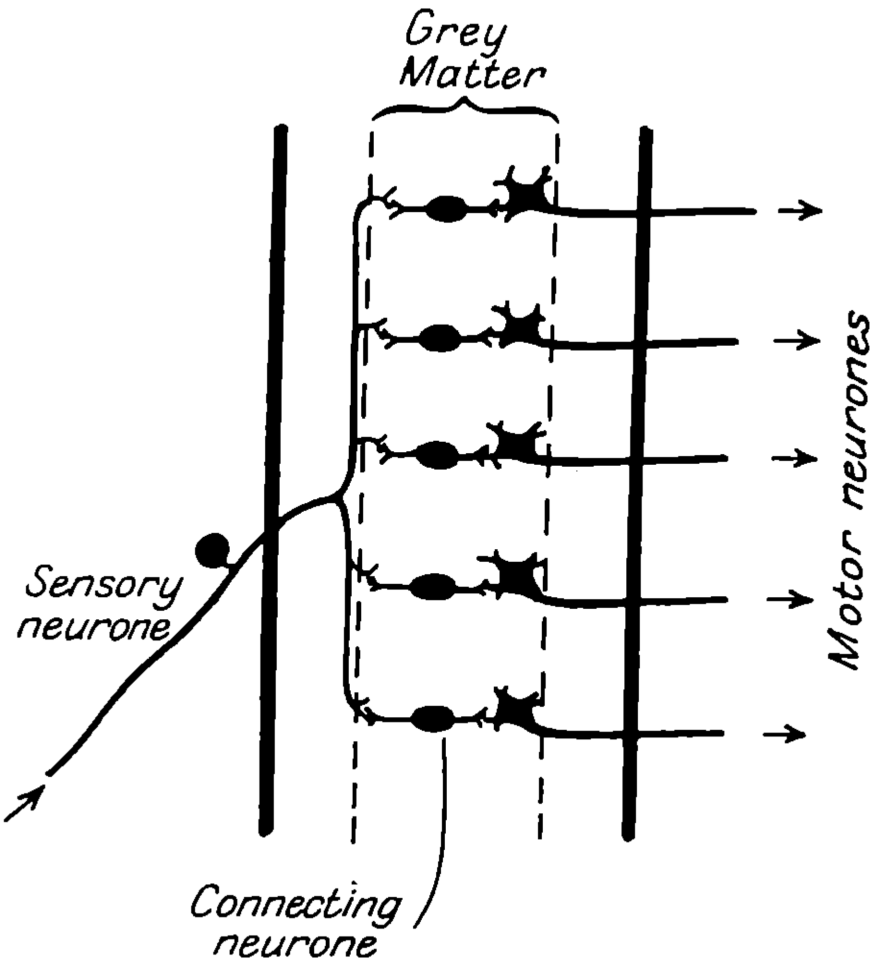


Fig. 63.—Vertical section of the spinal cord.

body of which lies in the cerebrum. This, therefore, is the pathway by which sensations reach consciousness. The cerebrum can also initiate voluntary muscular movements which are not mere responses to simple reflex actions. This is possible because motor neurones of the cerebrum have axons which extend down the spinal cord and come into contact with those motor neurones whose axons terminate in muscles. Notice that in Fig. 64 the sensory and motor axons which travel through the spinal cord to the brain cross over from one side to the other. Thus, the left side

of the cerebrum is concerned with sensation and movement on the right side of the body, and injury to one side of the brain commonly gives rise to paralysis of the opposite side of the body.

Conditioned Reflexes.—The natural reflex actions that we have been considering are called *simple reflexes* to distinguish them from another kind, *conditioned reflexes*. Conditioned reflexes will best be understood by considering

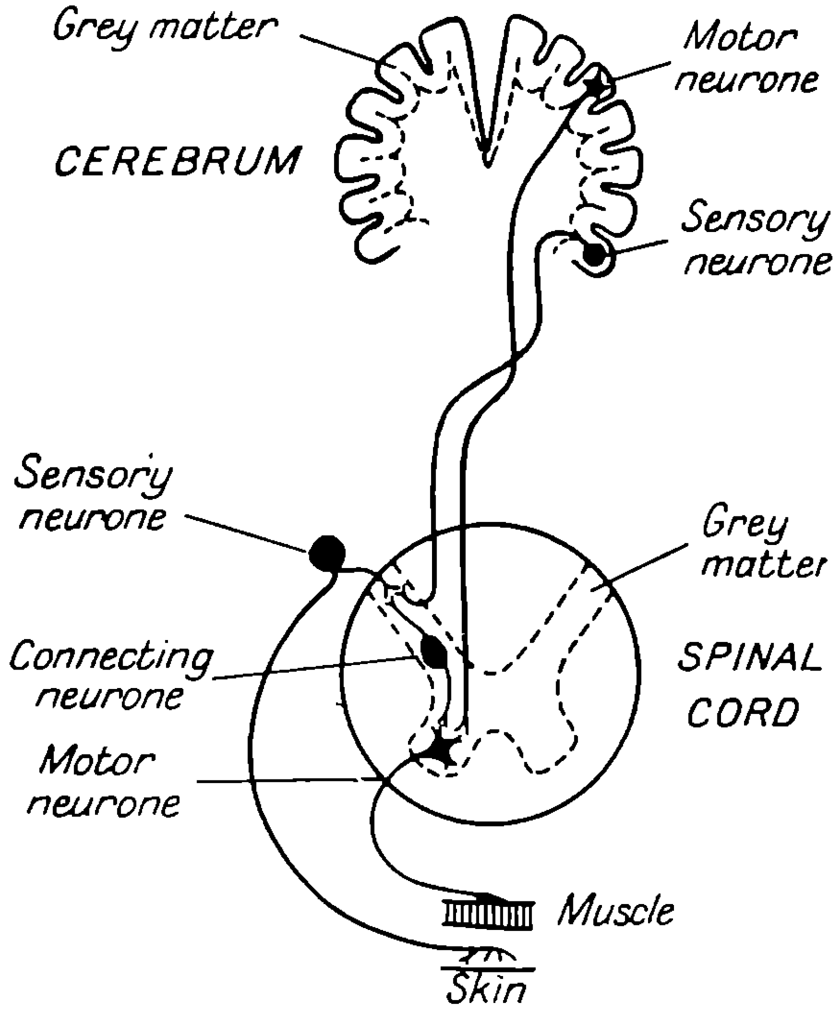


Fig. 64.—Connections between spinal cord and cerebrum.

a simple description of the experiments which led to their discovery. A Russian physiologist, Pavlov, observed that when a dog saw his dinner in front of him, his mouth was filled with saliva. This was a simple reflex action, obviously designed by Nature to prepare for the digestion of the food. Pavlov arranged that a dog should be presented with his dinner at a certain time every day while a bell was rung simultaneously. This introduced a new sensation, a sensation of sound in addition to that of sight. After some weeks it was found that the ringing of the bell gave rise to the

flow of saliva even when there was no dinner. Thus the reflex activity had been brought about in response to a new kind of stimulation quite different from Nature's original intention and Pavlov termed this a conditioned reflex. Many of our own activities are of this nature and education is partly concerned with training children in conditioned reflexes. For example, such an activity as swimming has to be learned by conscious effort, but eventually becomes a succession of conditioned reflexes unconsciously carried out as soon as the body feels itself to be immersed in water. The reader will no doubt be able to think of other examples in everyday school life.

Inhibition.—It will be remembered that the brain is essentially a controlling part of the nervous system, and we can consciously interfere with the activities of lower nerve centres. Suppose (referring to Fig. 64) that instead of a pin being stuck into the skin of the hand, a friend was using a needle to remove a splinter. This would cause pain and would lead to reflex withdrawal of the hand. The conscious mind, however, realizes that the pain is serving a good purpose and should be borne, and so the cerebrum, by means of its connections with the spinal cord, prevents the motor neurone of the cord from making the muscle contract. This is termed *inhibition*. A woman, taking a kettle from the fire, may find that the handle is hot and burns her hand. Reflex action would lead her to drop the kettle immediately. If her child is playing on the hearth it might be scalded, so she inhibits the reflex action, or delays it until she can put the kettle down in a safe place. The psychological attribute of self-control is largely a matter of inhibition and the higher animals have greater powers of inhibition than have the lower. Higher types of men also possess this power in greater degree than lower types. Training in inhibition forms part of the education or upbringing of a child. The baby has to learn to inhibit the indiscriminate reflex activities of the rectum and bladder, while the older child has to learn wider lessons of general self-restraint in all its behaviour.

Irritability.—Table I states that irritability is one of the characteristics of living matter and it is a characteristic particularly developed in some cells of the nervous system. The power of conduction is of no use unless an appropriate cell is sensitive to stimulation or irritation in the first place. In the examples of nervous activity which have already been given the story has always commenced with some stimulus (such as a pin prick) being applied to a nerve ending which then gives rise to conduction in a series of neurones.

Common Sensation.—We have already seen that nerve endings are present in the skin : they are the terminations of the axons of sensory neurones. By means of these nerve endings we are able to appreciate sensations of touch, pressure, temperature and pain, but the precise form of the nerve ending varies according to the sensation which it is designed to detect. Because these sensations can be experienced with any part of the body, they are collectively termed *common sensation*. All parts of the skin are not responsive to the same sensations, especially where temperature is concerned. On the forearm, for example, there are "cold spots" which experience a sensation of coldness, even when stimulated by very hot water. This is because the nerve ending is only capable of responding to stimulation in one way no matter what the stimulus may be. Moreover, some parts of the skin are more sensitive than others. Thus, two pin points gently placed upon the skin of the finger end can be clearly differentiated, even when very close together. On the back, however, they are felt as one point, even when comparatively far apart.

Special Senses.—In contradistinction to common sensation there are others which cannot be detected by all parts of the body, but only by certain specialized organs. They are therefore called special senses. The rudiment of a special sense organ is indicated at A in Fig. 52. Here is a special cell at the surface of the animal communicating, by its axon, with the nerve centre. We can imagine that this cell disregards ordinary forms of stimulation and is only responsive to the action of light falling upon it. It

would thus represent a primitive eye. No other part of the animal would be sensitive to light because it would lack the specialized cell.

In man the special senses are *vision*, *hearing*, *taste* and *smell.* Vision and hearing play important parts in education and require detailed consideration. A chapter on each occurs in Part III. The other special senses will be briefly discussed here.

Taste.—The tongue has three functions. It is the organ of taste, it is used for speech, and its movements are important in pushing food between the teeth and in the act of swallowing. At present we are only concerned with the first of these functions. The primary object of the sense of taste is to enable us to choose food, rejecting that which is unsuitable. In order to experience taste, it is, of course, necessary that food should be in actual contact with the tongue.

Structure of the tongue.—The tongue is a large, fleshy mass (Fig. 28) composed chiefly of muscle cells which render it capable of movement. The surface of the tongue is studded with projections (*papillæ*) which are more marked in the rough tongue of the cat than in man. In the papillæ are the special cells of taste, forming little collections known as *taste-buds.* Each taste-cell sends a long fibre to the brain to inform it of what is being tasted in the mouth.

Tastes.—The tongue is able to distinguish a number of primary tastes: sweet, sour, salt, bitter or acid, alkaline and (according to some people) metallic tang. The wide range of tastes with which we are familiar is due to combinations of these primary tastes and also to the use of the sense of smell. It is well-known that a cold in the nose impairs the taste of food and nasty medicine may be rendered almost tasteless by holding the nose. Different parts of the tongue are sensitive to different tastes. The tip and sides appreciate sweetness and sourness, the back of the tongue detects acidity and so on. Information of this kind is acquired by touching the tongue with a small brush dipped in a mixture of glycerine and quinine. The sweet glycerine is detected in one region, but in another

region the mixture tastes bitter owing to the quinine. If one part of the tongue is anæsthetized a certain taste may be lost, thus showing the area which is normally sensitive to that taste. The taste-cells can only come into contact with food if this is in solution either in water or in the saliva. Perfectly dry substances have no taste until they become moist in the mouth. The sensitivity of the taste-cells is also diminished if the food is very hot or very cold. Another way of taking nasty medicine is to wash out the mouth with hot water or iced water as a preliminary. Common sensation, such as touch or pain, is detected by ordinary nerve endings in the tongue which are quite distinct from the special taste-cells.

Smell.—Smell is another special sense which is of assistance in choosing food. It is intimately connected with the sense of taste as has already been mentioned. Smell, again, like taste, is a sense which requires contact between the body and the object smelled. Fine, odoriferous particles in the air enter the nose and stimulate this sense.

Structure of the nose.—The internal structure of the nose has been described in Chapter 6. Fig. 28 shows the three bony shelves between which the air flows on its way to the throat and windpipe. The special *smell-cells* line the region between the uppermost shelf and the roof of the nose. They communicate with the brain by means of nerve fibres which pass through the roof of the nose. In ordinary quiet breathing the air passes chiefly between the lowest shelf and the hard palate and very little comes into contact with the smell-cells. Therefore, when we want to smell anything distinctly, we sniff vigorously, and thus draw the air up to the specialized cells. Human beings do not use the sense of smell to the same extent as many of the lower animals. In the dog, for example, smell-cells line the greater part of the nose and are not restricted to one region.

Smell differentiation.—The nose is able to appreciate a number of different scents and can, in addition, experience common sensation such as pain, heat or cold. Moreover, certain substances give rise to a sensation of stinging

(ammonia, pepper) which is not the same as smell, although always associated with the scent of these substances. Some people are insensitive to certain scents (violets, for instance), a phenomenon analogous to colour-blindness. Continual exposure to one smell may render anyone temporarily insensitive to it. A slight escape of gas may be very noticeable as you enter a room, but ten minutes later you cannot detect it. A mixture of strong smells may neutralize each other. Iodoform and balsam of Peru each has a strong and distinctive perfume: suitable proportions mixed together give a combination which is without smell.

Muscle and Joint Sense.—Both common sensation and the various special senses are concerned with happenings outside the body or upon some point of its surface. We are also able to experience sensations which have their origin inside the body. We do not need to look at our hands to know whether the fingers are moving or stationary. We do not need to look at our legs to know that the right is crossed over the left. Nerves run to muscles, of course, causing them to contract when required. These nerves contain the axons of motor neurones. In addition to motor neurones, the axons of sensory neurones run to all muscles and joints. Through these we are made aware of the extent of movement at a joint or the degree of contraction which is taking place in a muscle. Muscle and joint sense not only enables us to know the position of the limbs but (especially in the case of the hand and arm) enables us to judge the weight and size of objects which we handle. Nowadays it is realized that the cultivation of this sense should receive attention during a child's education and it becomes doubly important when one of the other senses (such as sight) is impaired. Muscle sense also enables us to judge the distance of objects. The closer an object is to the face, the more the eyes have to turn inward to regard it (Chapter 20). The eye movement is brought about by the action of muscles and we estimate the degree of movement, and thus the distance of the object, by muscle sense. Lacking experience in judgment of this kind, a baby may reach out its hand for the moon or other distant object.

CHAPTER 10

THE ENDOCRINE ORGANS

In Chapter 9 we saw how the activities of the body are controlled and co-ordinated by the nervous system. From the examples of nervous activity which were given, it would be seen that the nervous system is chiefly responsible for rapid responses to various kinds of stimulation. Apart from these day to day activities of the body, there are other, slower activities which are only manifest over long periods, such as growth, development, and the formation of character and temperament. These activities are governed by a number of organs termed *endocrine organs.*

Endocrine Organ and Hormone.—An endocrine organ is a collection of cells producing a liquid chemical substance termed a *hormone.* The hormone of an endocrine organ filters into the blood stream as the blood flows in capillaries amongst the cells of the organ. In this way the hormone is able to travel to other parts of the body where it influences the behaviour of other cells. Since an endocrine organ produces a liquid it may be called a gland and these organs are often known as *ductless glands.* Sweat glands, salivary glands, and others that have been mentioned have each got a duct or tube leading from the gland to some other part of the body and so conveying the gland's secretion to where it is wanted. The term ductless glands is applied to the endocrine organs because, although they are glands of sorts, they have no such pipe or duct, but pass their products directly into the blood stream.

No attempt will be made to describe all the endocrine organs, but four will be given as examples to show the kind of work which these organs do.

Pituitary Body.—The pituitary body is a collection of cells forming a small, fleshy mass about the size of a pea. It lies below the brain on the floor of the cranium. It produces a number of hormones, one of which influences the growth and form of the body. If this hormone is lacking, or is produced in insufficient quantity, the individual concerned becomes fat. There are, of course, other causes of fatness, and every stout person is not necessarily suffering from pituitary defect. If this lack of pituitary hormone occurs during childhood, not only does the child become fat but it also fails to show proper sexual development.

In other cases there may be an excess of pituitary hormone. This leads to considerable overgrowth of the skeleton, and

FIG. 65.—Changes due to pituitary disease (by permission from Schäfer's *The Endocrine Organs*).

a child with this complaint may grow to a considerable height, becoming a giant. If the pituitary body becomes over-active in an adult and produces excess of its hormone, giantism does not result because the skeleton has long ago finished growing. The only parts which can still grow are the extremities, the hands, feet and head. Individuals affected in this way tend to have large feet, broad, spade-like hands, and a very massive head with pronounced lower jaw. Fig. 65 shows four photographs of a man over a period of twenty years, during which his pituitary body became increasingly active. Notice how the head has become more massive and the features coarser and heavier. Such a change is generally due to some disease of the pituitary body. If the photographs were of four different people, there would be nothing surprising about it, and it is easy

to suppose that slight differences in the amount of this hormone (amongst other things) in different individuals give rise to different facial appearances.

Thyroid Gland.—The thyroid gland is a fleshy mass about the size of a chestnut, situated in the front of the neck, just below the skin (Fig. 70). Ordinarily it is so soft that the tension of the skin is sufficient to press it out flat so that its presence is unnoticed. When this gland is diseased it sometimes becomes harder and firmer, forming a definite swelling of the throat which is known as a *goitre*, or sometimes as Derbyshire neck, from the district where it was at one time common. The hormone produced by this gland is known as *thyroxin*, and it contains a good deal of iodine. Since iodine is largely derived from fish in our diet, it is easy to see why the thyroid gland should have been so often at fault in an inland district like Derbyshire in the days when fish could not be rapidly transported far from the sea coast.

Thyroxin controls the chemical activities of the body cells with which it comes into contact through the blood stream. If there is too much of it the body's activities are speeded up and the individual lives at a faster rate. The heart beat and respiration are more rapid and the person is often nervous, excitable and "jumpy."

When there is not enough thyroxin manufactured by the thyroid gland the rate of life is slowed down. The heart beat and respiration are slower and the individual tends to be placid, lethargic and dull. In the case of a child, growth and development are arrested and a dull-witted dwarf is produced. Such a person is called a *cretin* (Fig. 66).

Pancreas.—The pancreas or sweetbread has already been mentioned (Chapter 7) as one of the digestive glands. It is also an endocrine organ, as some of its cells manufacture a hormone known as *insulin*. Insulin does not pass into the alimentary canal along with the ordinary digestive juice, but like all hormones passes directly into the blood stream. This hormone is necessary for the body to utilise sugar. Sugar is digested in the alimentary canal and then

absorbed into the blood. But without insulin the cells of the body cannot use this sugar. If there is a lack of insulin, sugar simply accumulates in the blood, giving rise to the condition known as *diabetes.* If, on the other hand, there is too much insulin, then sugar is used up too rapidly and the body is unable to store it up for emergencies, but this is a rare abnormality.

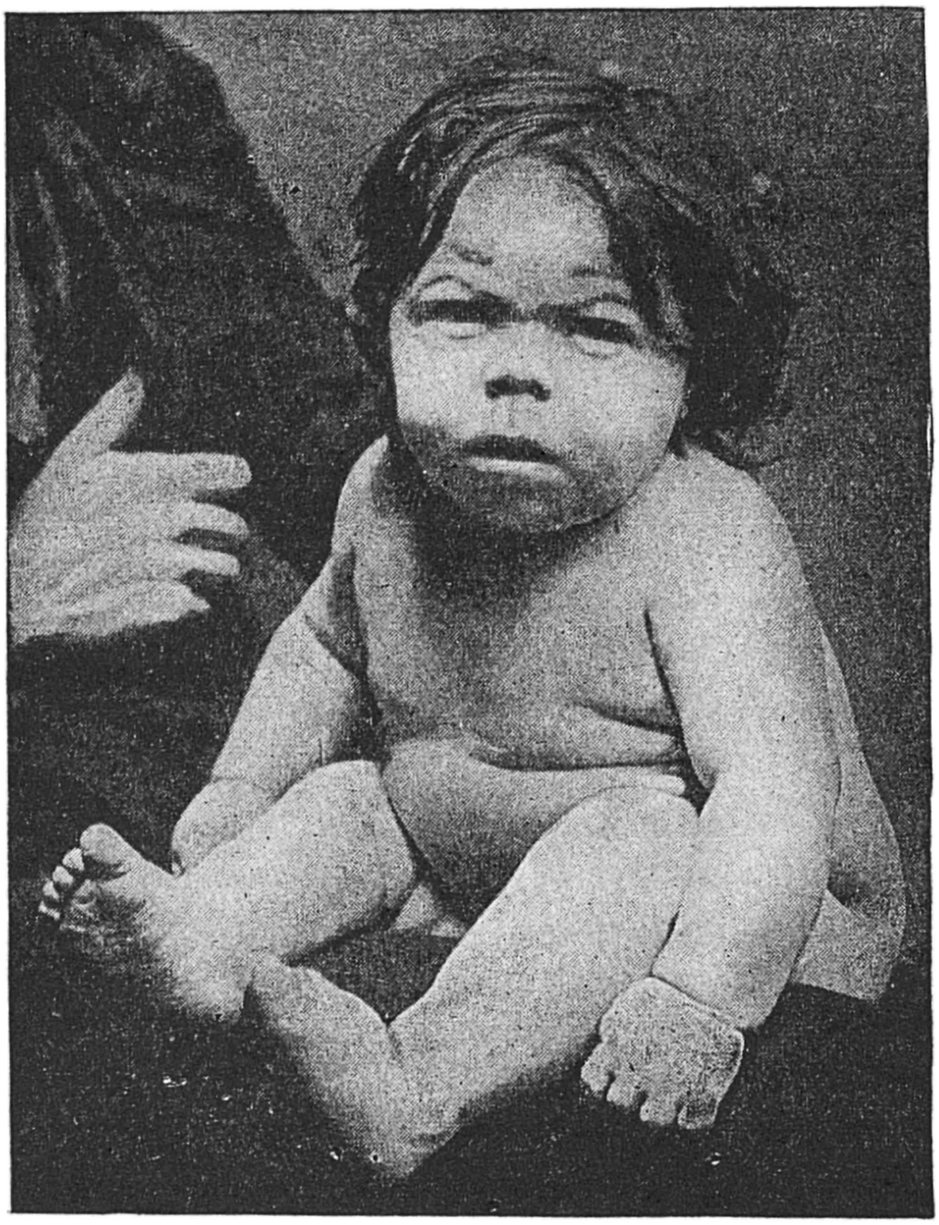


FIG. 66.—Cretin, showing characteristic facies (by permission from Hutchison, *Diseases of Children*).

Adrenals.—The adrenal bodies are endocrine organs, each about the size of a walnut, which rest upon the upper end of each kidney. The Latin word for the kidney is "ren," and adrenal simply means "near the kidney." These bodies are also known as *suprarenal glands.* They produce a hormone called *adrenalin.* Adrenalin is poured into the blood stream at times of excitement, danger, fear

or rage, and it is responsible for the physiological changes which accompany these emotions. These changes are increased rapidity of the heart beat leading to a better circulation of the blood, blanching of the face since blood is diverted from here to the muscles of the limbs, and (in fear at any rate) standing up of the hair. These phenomena are better seen in an angry, excited animal than in a human being. They are obviously of a protective character, and prepare the animal for fighting or running away as circumstances dictate. It is for this reason that blood flows from the face, where it is not wanted, to the limbs where it may be required for rapid muscular movement.

These four examples of endocrine organs show the way in which personal appearance, temperament, nutrition and emotion are influenced by chemical substances circulating in the blood. The nervous system and endocrine organs together control all the rest of the body. They may be compared to the services of the post office. When messages have to be sent in a hurry, by telegraph as it were, the nervous system is employed, but the endocrine organs correspond to the slower letter-post for matters which are not so urgent.

CHAPTER 11

REPRODUCTION

It will be recalled that reproduction is one of the essential characteristics of life (Chapter 2). Perhaps it is the most important characteristic of living cells as, once life began on the earth, this power enabled it to continue and to spread. Fig. 67 shows some stages in the reproduction of an amœba. When the animal has reached a certain size and age, it divides in half, the nucleus first and then the

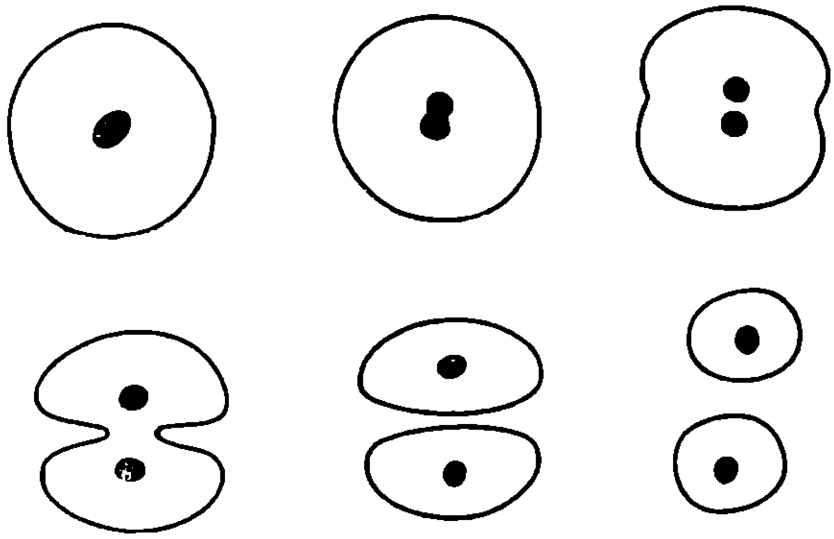


FIG. 67.—Reproduction in the amœba.

rest of the protoplasm, so that two independent cells are formed. The most important changes are those which take place in the nucleus, but they are too complicated for detailed discussion here. Most of the cells in the human body have the power of reproducing in this manner. The body is thus able to grow (in the case of a child) and to repair injuries by producing new cells when they are required. Sometimes cells reproduce when there is no injury to repair, giving rise to an unwanted mass of flesh, popularly termed " a growth." This may, or may not, be

a serious thing, according to the region of the body involved, and according to the reproductive activity of the cells.

Reproductive System.—Apart from purposes of growth and repair, reproduction is necessary for the production of new individuals for the continuation of the species. The organs concerned with this aspect of reproduction constitute the reproductive system. Very low down in the scale of life certain cells of animals and plants specialize in reproducing to the exclusion of other forms of activity. Also far down the scale Nature begins to make use of parents, that is two animals (or two plants) which jointly give rise to offspring. The essential process, however, is not very different from the reproduction of the amœba. A reproductive cell divides into two but, instead of forming two new individuals, one cell remains attached to the parent (to continue reproducing by further divisions) and the other is cast off. The cast off cell unites with a similar cell from the other parent and the two fuse together. From this new cell a new individual is formed (by continued cellular division) which, of course, inherits the general characteristics of both parents as it partakes of the protoplasm of each.

Development of Young.—After the union of the parental cells in lowly forms of life, the parents have no further interest in their offspring. The developing fish or the young tadpole is exposed to all kinds of dangers and must take its chance of survival to adult life. The wastage of young in these cases is tremendous and both fish and frogs lay very large numbers of eggs to ensure that some new individuals, at least, shall survive. In the case of birds far fewer eggs are laid but the parents watch over their developing offspring until they are old enough to fend for themselves. This is a more efficient and more economical way of reproducing than that seen in lower creatures. The animals, known as mammals (of which man is one), use a still more efficient method. The young mammal develops within the body of the female parent until it is fit to face the world as a separate individual. In

such a creature as the kangaroo the young animal is actually born incompletely developed, but is immediately placed in its mother's pouch until development is finished. Another exceptional mammal is man. At birth a human being is fairly complete in a physical sense (though needing to increase in size) but has to undergo a long period of training and upbringing before it can fend for itself. No other animal has such a long period of childhood as man. It is in the case of mammals that the value of having two

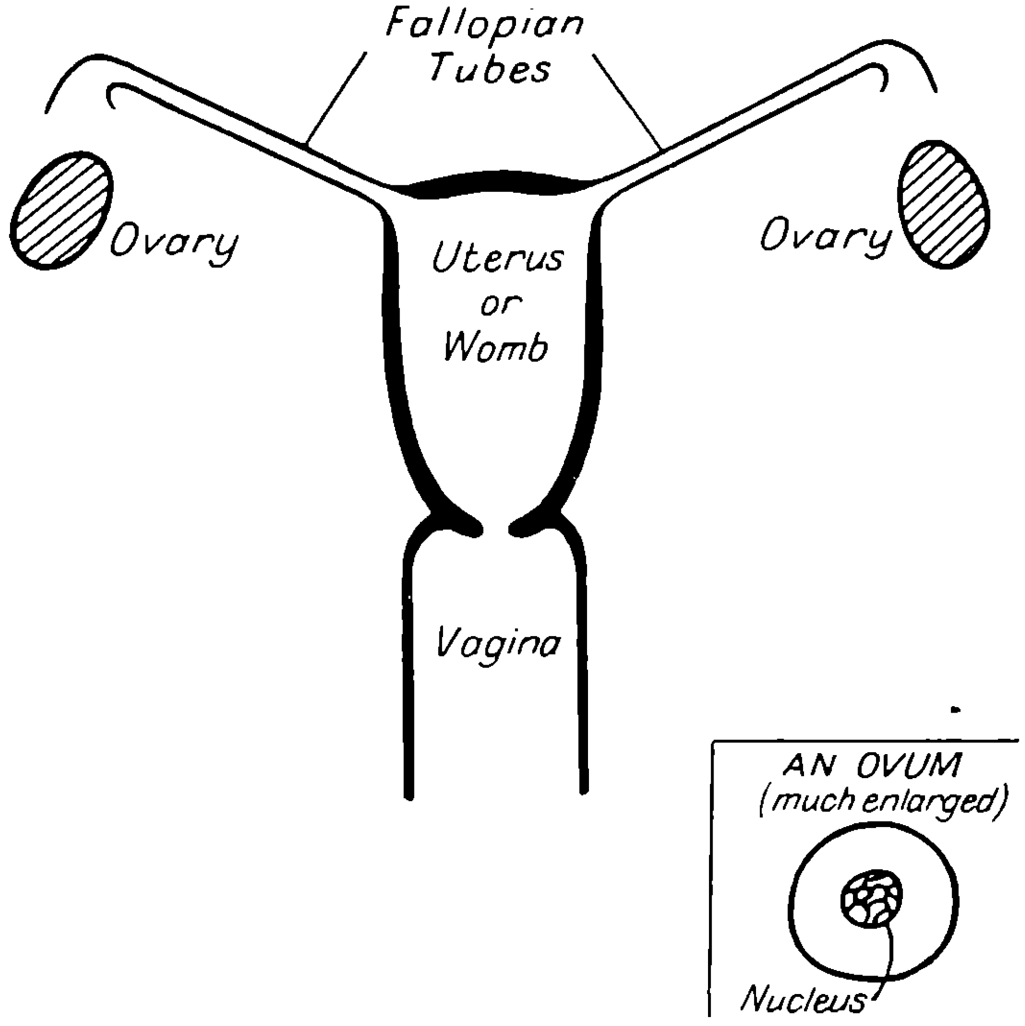


FIG. 68.—Diagram of a female reproductive system.

parents is best seen. The female specializes in looking after the young (both before and after birth), while the male seeks food and protects the family. These duties can be carried out more efficiently when divided between two individuals in this way.

Reproductive Organs. ***Female organs.***—In the higher animals and man the essential female reproductive organs are the *ovaries* (Fig. 68). The human ovaries are two oval, fleshy masses, each about an inch in length,

lying on either side of the lower abdomen within the pelvic girdle. The ovaries produce the female reproductive cells which are known as *ova* (singular, ovum). The *uterus*, or womb, is a muscular bag (about three inches in length) which lies behind the bladder, in front of the rectum, and has the ovaries on either side. The uterus communicates with the ovaries by two hollow tubes (*Fallopian tubes*) and with the exterior of the body by a wider tube, the *vagina*.

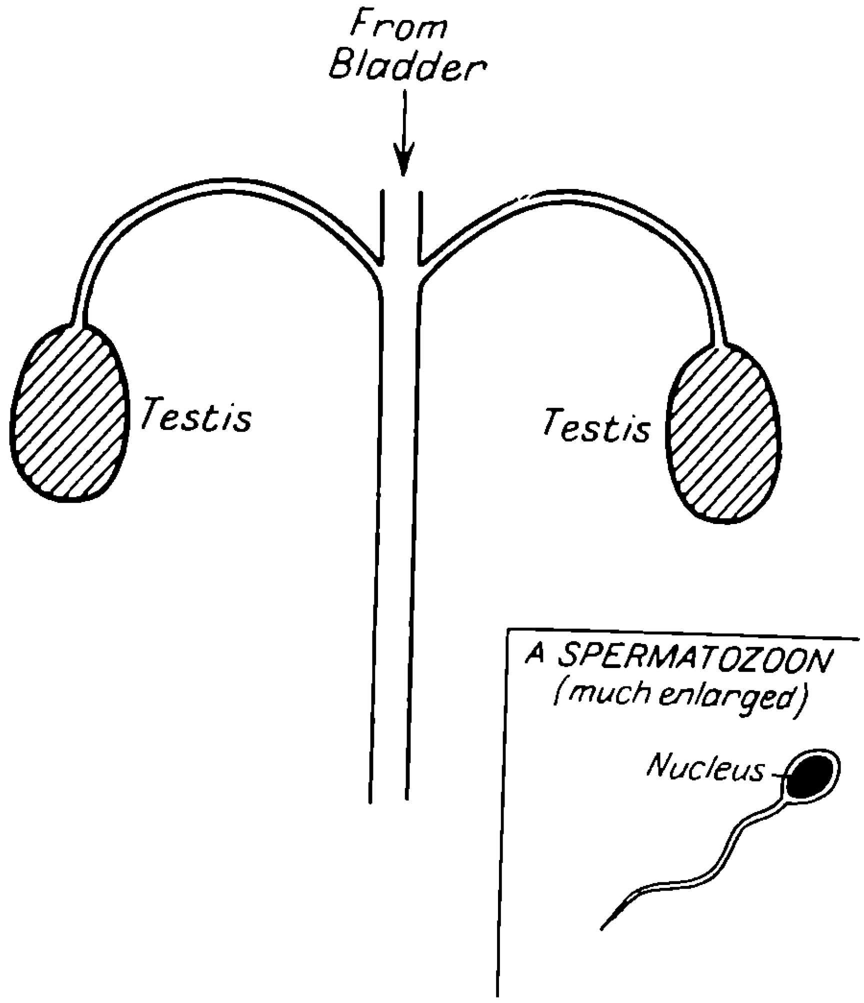


FIG. 69.—Diagram of a male reproductive system.

Male organs. The essential male organs of reproduction are the *testes* (singular, testis). These are two bodies, very much like the ovaries in general appearance and dimensions, but producing male reproductive cells, instead of ova. The male cells are called *spermatozoa* (singular, spermatozoon) and each has an elongated, protoplasmic tail by means of which it can swim (Fig. 69) in the fluid (*semen*) which the testis also produces. In man and many animals the testes are contained in a muscular bag, the scrotum, at the lower end of the abdomen. A thin

tube or duct leads from each testis to join the passage which conveys urine from the bladder (Fig. 69). This passage runs along the *penis* to the exterior.

Fertilization.—The blending together of a spermatozoon and an ovum is termed fertilization. It occurs in the uterus, to which the ovum has travelled along one of the Fallopian tubes and to which spermatozoa have travelled by their own efforts after the deposition of semen in the vagina. Although a very large number of spermatozoa are contained in semen, only one ovum is usually awaiting fertilization at any one time, and it is fertilized by only one spermatozoon. The new individual formed by this union therefore consists of a single cell, thus a human being begins with the simple structure of an amœba. The one cell quickly divides and re-divides, ultimately forming a complete human being, which is then expelled from the uterus by the contraction of its muscular walls.

Menstruation.—The lining of the uterus is continually undergoing change. Many blood vessels develop in it in preparation for the nourishment of a fertilized ovum. If fertilization does not occur the lining disintegrates and is shed with the discharge of blood which constitutes menstruation. In human beings this cycle of changes generally occurs regularly over a period of about four weeks.

Sex Hormones.—Both the ovary and the testis contain cells which produce hormones. They are thus endocrine organs (Chapter 10) as well as reproductive organs. Their hormones give rise to the production of the secondary sexual characteristics. These are the onset of menstruation, the development of the breasts and the like, in the case of females, and the breaking of the voice, the growth of hair upon the face and the establishment of a general masculine configuration in males. The different mental make-up of the two sexes is also due in part to the sex hormones.

CHAPTER 12

THE BODY AS A WHOLE. GROWTH AND DEVELOPMENT

It was emphasized in Chapter 9 that the various systems of the body, although described separately, do not in life work in an isolated fashion, as they are controlled by the nervous system. It must also be realized that these systems are not isolated structurally, but are greatly intermingled within the small compass of the body. Fig. 70 shows the trunk with the various internal organs in position. The chest contains the principal parts of the respiratory system, the lungs. The chest also contains the heart and the arteries and veins connected with it, parts of the circulatory system. The gullet, belonging to the digestive system, passes through the chest behind the heart and between the lungs on its way from the mouth to the stomach. All these organs are protected by being enclosed within the bony framework formed by the ribs, the spine and the breast bone.

The diaphragm separates the smaller cavity of the chest from the larger cavity of the abdomen. The diaphragm is pierced by holes through which pass the gullet and the aorta, travelling from chest to abdomen, and one of the great veins and the principal lymphatic channel on their way from abdomen to chest. Immediately below the diaphragm lie the liver on the right and the stomach on the left, and below these two part of the large intestine can be seen travelling from right to left. The junction of stomach and small intestine is deep down in the abdomen behind this portion of the large intestine. The main bulk of the small intestine almost entirely fills the lower half of

the abdomen, but at the extreme sides may be seen further portions of the large intestine.

Down the back wall of the abdomen, and behind the various structures just described, run the main blood vessels. The kidneys are also found on the back wall and

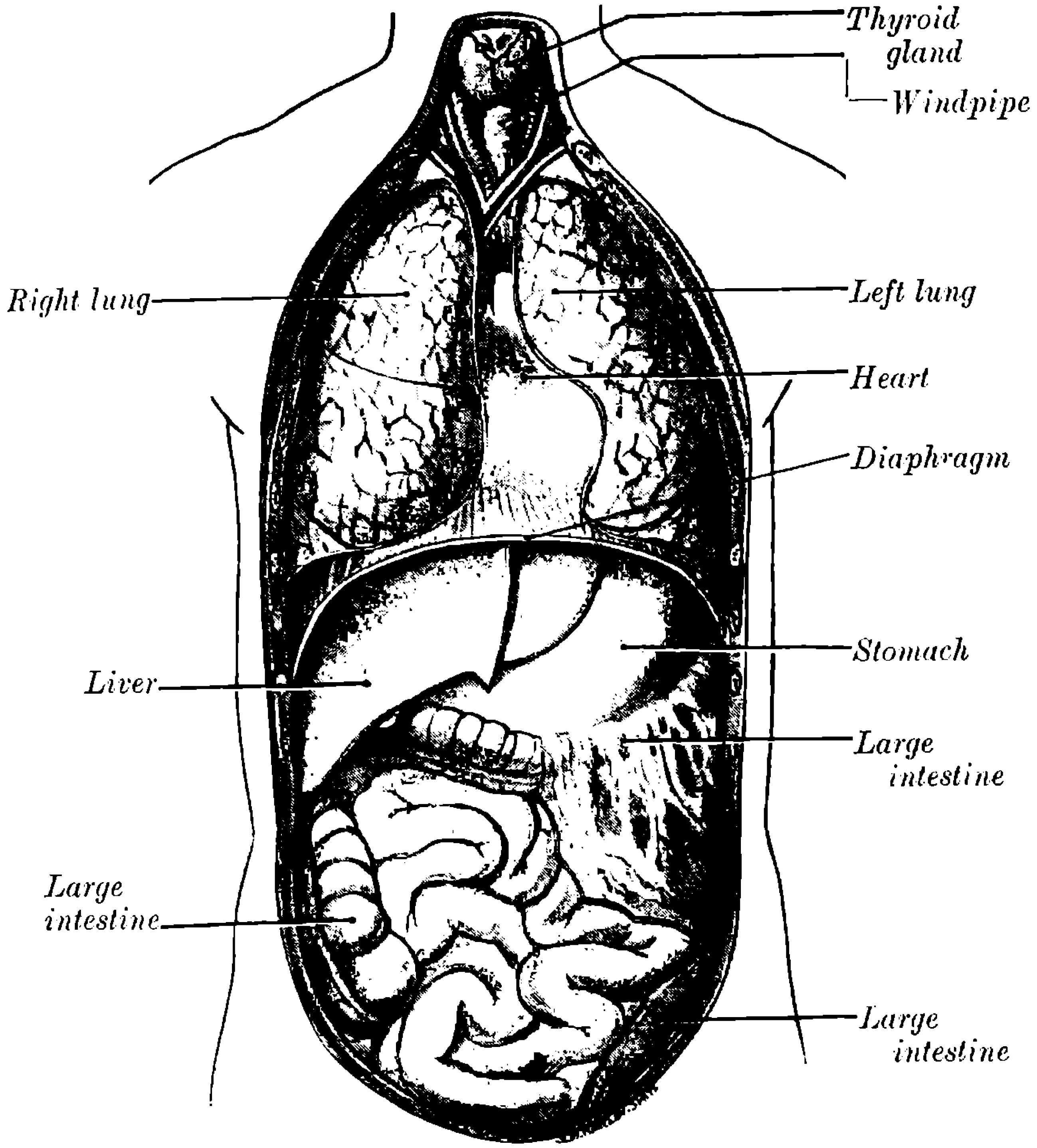


FIG. 70.—The organs of the body from the front.

they are connected by two fleshy tubes with the bladder at the very bottom of the abdominal cavity. Behind the bladder lies the rectum.

The spaces between the various organs of the body are occupied by fat and by fibrous material, no actual, empty spaces existing. It should be remembered that all parts of

the body are made of living protoplasmic cells, although these are not indicated in most of the figures in this book, being omitted in order to keep the diagrams as simple as possible.

Summary of Physiology.—The arrangement and work of the different components of the body may be summarized as follows. The cells of which the body is composed form tissues and organs which may be grouped together in systems. The skeleton is the supporting system, but it is mobile on account of the presence of joints between the bones. Movement is brought about by the muscular system. The whole body is nourished by the blood which not only conveys food and oxygen, but removes waste products. The blood is kept in motion by the action of the heart, which causes it to flow through the vessels which form the circulatory system. Lymph is a fluid, given off from the blood, which comes into more intimate contact with the body cells than does the blood itself. The respiratory system is responsible for supplying the blood with oxygen and for removing from it carbon dioxide. The alimentary canal and its associated glands form the digestive system and are responsible for keeping the blood supplied with food material. Waste products are got rid of by the excretory organs, the lungs, the kidneys and the skin. The body's general activities and reactions are co-ordinated by the nervous system and by the endocrine organs, while the reproductive system provides for the continuation of the species.

Growth and Development.—The foregoing summary represents the complete story of living as far as an adult is concerned. In the case of a child there is something more to be considered, as a child is immature and incompletely developed. The most obvious, physiological way in which a child differs from an adult is in increasing in size, that is, in weight and height. Proper increase in weight and height form a very good index of the state of a child's health, and it is a good practice for those having charge of children to weigh and measure them at frequent intervals. Increase

8

in weight and height do not usually occur at the same time: when a child is filling out it is not simultaneously increasing in length. Growth is affected by three factors: age, sex and season of the year. These must now be considered in more detail.

Growth and Age.—Table III shows the type of growth which goes on at different ages. During the first year of

TABLE III.—Growth at Different Ages

0-1 year.	General increase in bulk.
1-4 years.	First period of weight increase.
5-7 years.	First period of height increase.
8-10 years.	Second period of weight increase.
11-15 years.	Second period of height increase.
15-20 years.	General physiological development.

life there is a general increase in size, the body filling out in all directions. Following this is a period during which increase in weight is more marked than increase in height, although, of course, height is being put on to some extent. This lasts until about the age of four years. The next phase is one of marked height increase during which a child shoots up noticeably. From eight to ten, and from ten to fifteen, there are again periods of weight and height increase. Then, during the late teens, general physiological development takes place, the body changing from the childish to the adult form.

Table IV sets out these matters in a somewhat different form. During the first two or three years of life the child

TABLE IV.—Table of Growth

0-2½ years.	Large head and trunk. Short limbs. Much fat.
2½-6 years.	Transverse growth and extension of limbs. Still plump.
6-13 or 14 years.	Growth of limbs. Trunk relatively short.
14-21 years.	Trunk and limbs assume adult proportions.

is characterized by having a relatively large head and relatively short limbs, with much fat upon the body. This corresponds roughly to the first period of weight increase of Table III. From two or three, until the age of six, the limbs grow and become relatively longer in proportion to the trunk. This corresponds to the first period of height increase in the other Table. From six into the early teens, the growth of limbs continues so that the trunk is now relatively short and the child appears lanky, a phase also represented in the former Table. In the later teens the trunk and limbs assume the adult proportions.

Growth and Sex.—Growth and development vary not only according to the age of a child, but also according to its sex. At some periods boys tend to be bigger than girls, and at others girls outstrip the boys. This is shown in Table V.

TABLE V.—Sex and Growth

0-12 years.	Boys taller than girls of same age.
12-15 years.	Girls outgrow boys in height and weight.
15 onwards.	Males lead in height and weight.

Seasonal Growth.—The activities of most living things are influenced by the season of the year and increase of weight and height in children are not exceptions to this rule. Fig. 71 once more indicates that when a child is markedly increasing in weight, height is not increasing to any great degree. The greatest increase in weight takes place during the autumn, the body putting aside considerable reserves in preparation for the winter. During the winter, weight is still gained, but not to the same extent. In the hot months of the year increase in weight is least marked of all.

Gain in height is the converse of the foregoing. In the last third of the year, height is not gained to any marked extent. During the winter and early spring, the gain is more marked, and in the summer becomes greater still.

Phases of Development.—So far, we have considered only growth in the obvious physical sense. A child develops, however, in other ways as well. Fig. 72 represents three phases of development. In the first years of life the new individual is primarily concerned with establishing itself in the world. Its development at this period may therefore be termed nutritive, as feeding and sleeping are the most important activities. The young child is also very active,

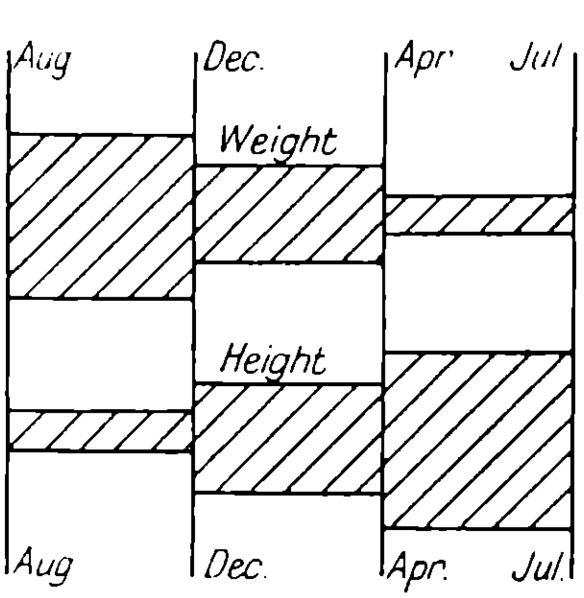


FIG. 71.—Seasonal growth.

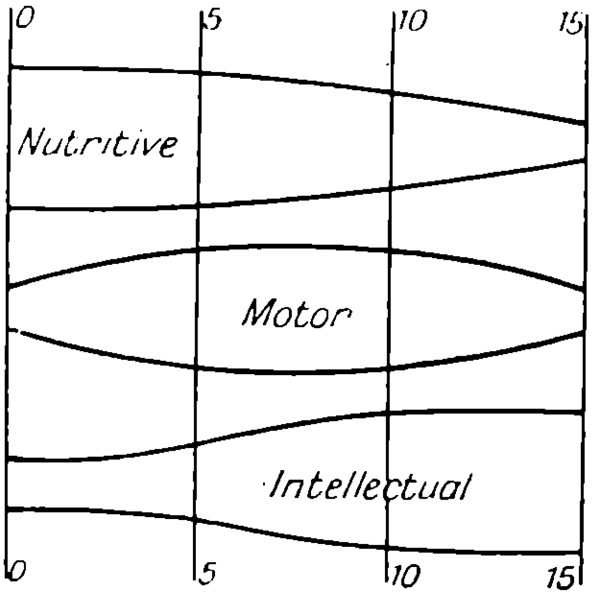


FIG. 72.—Phases of development.

and is undergoing what may be termed motor development, but this phase is much more marked during the next quinquennium. When motor development is most marked, from five to ten years or thereabouts, education should be largely a matter of activity and work with the hands, the child exploring the world and learning about it by means of his senses. Intellectual development, although present at the same time as motor, is more marked in the teens, so that this is the period most suited to learning in the more scholastic sense of the word.

PART II

NUTRITION AND DIETETICS

CHAPTER 13

FOOD

In the first section of this book, the working of the body has been described. We must now consider the food which is necessary in order to maintain the various body activities.

Uses of Food.—Food is necessary for three purposes :—

1. To supply energy.
2. To make good the wear and tear of everyday life.
3. In the case of a child, to provide for increase in size—growth.

Kinds of Food.—The diet of human beings varies considerably in different parts of the world and amongst different races and a single meal may contain a number of different ingredients. When submitted to chemical analysis, however, all the food which we eat is found to consist of ingredients which fall into three main chemical groups : *proteins*, *fats* and *carbohydrates.* Each of these yields energy to the body and so satisfies the first requirement of a foodstuff. Only the proteins can replace wear and tear and provide for growth.

Proteins.—Proteins are very complex organic substances. They enter into the composition of protoplasm itself, for this substance consists chiefly of protein and water. Gelatine is a familiar example of a protein and so is the white of an egg. Each of these forms a slimy mixture or

jelly with water, comparable to living jelly or protoplasm. Since protein is found in protoplasm it naturally occurs in all food materials which have been living things or parts of living things, whether animal or vegetable. Such foods as lean meat, cheese, eggs and milk are all protein foods. The living cells of plants are surrounded by fibrous, woody material, and so a vegetable food does not usually yield as much protein as does the same weight of an animal food, because part of the bulk of the plant is accounted for by the fibrous matter. Fleshy vegetables such as peas, beans and lentils (the leguminous group of plants) are exceptional in that they are quite rich sources of protein. Although protein can be got from both plant and animal foods, the animal sources are usually of more value in a diet. This is because the animal cells are more like our own and so their protein is more suited to our bodies' use. Protein of animal origin is often referred to as first-class protein.

Proteins supply energy to the body and can also be used to make new protoplasm which is necessary to replace cells which have worn out. In addition to making good wear and tear in this way, children (and immature animals generally) have to make new cells in order to increase in bulk to adult size.

Fats.—Under the term fats can be included all fatty, oily and greasy foods. Fats may be of animal origin (fat meat, butter, cream and lard) or of vegetable origin (olive oil, some kinds of margarine, and oils derived from certain nuts). Fats yield energy and are also stored beneath the skin, thus helping to keep the body warm, as explained in Chapter 8. They do not provide for growth or for the replacement of wear and tear, since they are not constituents of protoplasm. Both animal and vegetable fats are equally good as sources of energy, but the animal fats are preferable in a diet because they contain certain substances known as *vitamins* dissolved in them. These vitamins (described later) are absent from the vegetable fats.

Carbohydrates.—This is the chemical name for a group of substances which includes the starches and sugars.

Carbohydrate foods, therefore, are those which contain these substances, such as bread, potatoes, jam and sugar itself. Some animal foods contain carbohydrate, but the vegetable foods are the more important sources. Like fats, carbohydrates supply energy but cannot be used to make new protoplasm or new cells.

Balance of Diet.—As proteins fulfil all three uses of food and fats and carbohydrates do not, it may appear strange that we do not live upon proteins alone. There are several reasons why this is not practicable. It has been found that one class of foodstuffs is not digested and utilized satisfactorily unless the other two classes are also present in the diet. Moreover, proteins are very poor sources of energy, and it is more economical to get energy from fats and carbohydrates, using proteins only to make good wear and tear and to provide for growth. The three types of food ought to be present in the diet in certain proportions and in certain total quantities. Table VI shows

TABLE VI.—Atwater's Table of Daily Food Requirements

Foodstuff.	*Weight.*	*Proportion.*	*Calorie Value.*
Protein .	125 grammes	1	500
Fat . .	125 ,,	1	1100
Carbohydrate	400 ,,	3	1600
	650	5	3200

the calculations of a physiologist named Atwater. He estimated that an average man requires 650 grammes of food each day. This weight should be made up of 125 grammes each of protein and fat, and 400 grammes of carbohydrate. Instead of considering the actual weights, it is simpler, perhaps, to think of the proportions, thus one-fifth of the diet should be protein, one-fifth fat and three-fifths carbohydrate.

Calories.—The last column of Table VI shows the energy value of the different foodstuffs and some explanation

of this is necessary. When any substance is burnt it gives out heat and the quantity of heat is expressed in calories. One large calorie * is the amount of heat required to raise one litre of water 1° C. Food materials, like other substances, give out heat when burnt and it is usual to compare one food with another according to their heat value. It is true that the body does not burn up all the food to produce heat, since some of the energy extracted from the diet is used to produce movement, while some of the protein food is used to make protoplasm and not as a source of energy at all. Nevertheless, a given quantity of food would give out so many calories of heat if it were completely burnt up in a suitable machine and consequently the calorie value of any article of diet is a useful measure of its value. The Table shows that 125 grammes of protein yield 500 calories of heat when entirely burnt up. The same weight of fat yields more than twice as much heat, which illustrates that fats are better energy providers than protein. 400 grammes of carbohydrate, that is about three times the weight of fat, yields only 1600 calories, showing that carbohydrates are not such good energy providers as fats. Carbohydrates are very quickly digested, however, and so their energy is available comparatively soon after a meal. It is not uncommon for athletes to eat a little sugar shortly before a race in order to benefit from the additional energy provided. Fats take longer to digest, but eventually supply a considerable quantity of energy. The carbohydrate in a meal gives the body energy before the more valuable fats have become available.

Diet and Age.—So far we have been considering the dietetic requirements of a normal man. Children, women, or men doing abnormal work have somewhat different requirements. These are shown in Table VII. The first column of this Table indicates the type of individual. The second column the calorie value of the diet. It is perhaps easier to follow the third column, which shows the proportions of a normal man's diet which each individual requires :

* 1000 times the small calorie, the one usually used in physics.

the normal man's requirements being represented by the figure one. It will be seen that a boy aged sixteen years or over has the same requirements as a man. A woman, a girl over sixteen, or a boy between the ages of fourteen and sixteen all require eight-tenths of the normal man's diet. Notice that a child of two, although only about one-tenth of the age of a fully grown man of twenty-one, nevertheless needs about three-tenths of his dietetic requirements. In other words, a growing child needs more in proportion to its size than does an adult, because the

TABLE VII.—Dietetic Needs of Different Ages, Sexes and Conditions

Individual.	*Calories.*	*Proportion.*
Man ordinary light work	3000	1·0
Child 21-16 boy .	3000	1·0
girl	2400	0·8
16-14 boy	2400	0·8
girl .	2100	0·7
14-10	1800	0·6
10-5	1500	0·5
5-2	1200	0·4
under 2	900	0·3
Man manual work .	4500	1·5
heavy manual work .	6000	2·0
Woman ordinary light work	2400	0·8

child is increasing in size as well as using up energy. A baby's stomach, however, is small in proportion to its size and therefore it should be given small meals, frequently repeated during the day.

The Table also gives figures for men doing other than average work. A manual labourer or a soldier may need half as many calories again as an average man in their daily diet. Men doing exceptionally heavy labour, such as the lumber men of America, may have twice the caloric requirements of an ordinary city dweller. They obtain this great quantity of energy from a diet which is rich in fats.

Vitamins.—At one time it was thought that proteins, fats and carbohydrates were the only things necessary for a complete diet. During the course of some experiments, a number of rats were fed upon a diet which contained only these ingredients, although in a highly purified state. Contrary to expectations, the rats failed to thrive and showed certain symptoms of disease. It was then discovered that the addition of a little raw milk to the diet greatly improved the health of the animals. The quantity of milk was very small, about a thimbleful for each rat, and so it seemed obvious that the benefit was not due to any protein, fat or carbohydrate which might be contained in such a small amount of milk. The unknown ingredient of milk which produced this beneficial change was called a *vitamin*. As a result of careful investigation a number of vitamins have been discovered. As long as their chemical nature remained something of a mystery, they were labelled by the letters of the alphabet, A, B, C, etc. In some instances their chemical composition is now known, and they can even be manufactured artificially, but the old practice of alphabetical nomenclature still persists. Table VIII summarizes some of the important points about vitamins.

Vitamin A.—This vitamin is present in fats and oils of animal origin as shown in the Table. Cod and halibut liver oil are not ordinary articles of diet, it is true, but they form very useful additions to the diet in cases where vitamin A would otherwise be lacking. In the vegetable kingdom this vitamin is found chiefly in those roots and fruits which are red or yellow in colour. Vegetable oils (such as olive oil) do not usually contain vitamin A, nor is it present in pig-fat (lard) unless the animals have been pasture fed and not confined in a stye. The vitamin resists cooking if not too prolonged, but is more resistant if oxygen is excluded during the heating process.

If vitamin A is absent from the diet, a number of effects may be observed. Two of these are important in children. The child does not grow satisfactorily and also becomes

TABLE VIII.—VITAMINS

Vitamin.	*Sources.*	*Notes.*	*Uses.*
A	Fat meat. Butter. Cream Milk. Cheese. *Cod liver oil. *Halibut liver oil. Spinach. Cabbage. Carrots. Tomatoes.	Not usually present in lard, pork fat or oils of vegetable origin. Fairly resistant to cooking, especially if oxygen is excluded.	Necessary for growth. Raises resistance to infection. Absence leads to certain eye diseases.
B	*Outer husks of cereals (rice, wheat, barley, oats). *Leguminous vegetables (peas, beans, lentils). Green vegetables. Liver. Eggs. Milk. *Yeast.	Vitamin B consists of several fractions which vary in their resistance to cooking.	Absence of B_1 causes beri-beri. Absence of B_2 causes pellagra. Absence of B_3 and B_5 causes loss of weight. Absence of B_4 causes failure to grow.
C	Acid fruit juices (*lemon, *orange, apple, *grape-fruit). Cabbage. Swedes.	Easily destroyed by cooking, especially with alkalies. More resistant if air is excluded. Present in peas only when germinating.	Necessary for health of blood-vessels and gums. Absence causes scurvy.
D	Eggs. Butter. Cream. Milk. *Cod liver oil. *Halibut liver oil.	Can be made in the body under the influence of sunlight.	Necessary for the formation of bones and teeth. Absence causes rickets.
E	Meat. Eggs. Milk. Lettuce.	Not yet shown to be necessary for human beings.	Necessary for reproduction (in rats at least).

* = Rich sources.

Note : Nomenclature and ideas about vitamin B are undergoing revision at the present time.

more susceptible to infection by germs, catching colds, for example, more readily than usual.

Vitamin B.—Originally, the letter B was allocated to what was thought to be a single vitamin. This has now been shown to consist of at least six fractions known as B_1, B_2, B_3, etc. All of these are found in the same articles of diet as set out in Table VIII. Notice that vegetable foods predominate as sources of vitamin B. In cereals, the vitamin is contained in the husk and this is usually thrown away in refining flour for bread. Hence white bread does not contain the vitamin while brown bread does. In some parts of the world rice is the staple diet of the population, who may eat hardly any other food. If the husk of the rice is removed (in the process known as polishing) a disease called *beri-beri* occurs. A symptom of this disease is inflammation of the nerves and it occurs when vitamin B_1 is missing from the diet. In England, the B_2 and B_4 fractions are more important, and deficiency of these leads to loss of weight and failure to grow at a normal rate. Some of the fractions of vitamin B resist cooking fairly well but others may be destroyed by heat.

Vitamin C.—Vitamin C is found chiefly in plant foods as the Table shows. It occurs in most fresh vegetables and some fruits, especially those with acid juices. In vegetables such as peas, the vitamin only occurs during germination, that is when the seed is just sprouting.

Absence of vitamin C from the diet leads to *scurvy* (nothing to do with scurf or dandruff of the hair). Scurvy is characterized by fragility of the capillaries so that they easily rupture and allow blood to escape, giving rise to bleeding in certain situations, notably from the gums.

Cooking readily destroys vitamin C, particularly if alkalies are used. Hence the practice of boiling cabbage with soda, to preserve the green colour of the vegetable, is not hygienically sound.

Vitamin D.—Like vitamin A, this vitamin is found in animal fats and oils, but it is not present to any great

extent in vegetables. Vitamin D can also be produced in the human body. The layer of fat beneath the skin contains a substance which is known as *ergosterol.* When the sun shines upon the skin, the ultra-violet rays penetrate to the layer of fat and convert ergosterol into vitamin D. Exposure to sunshine (real or artificial) can compensate, to some extent, for dietetic deficiency in this vitamin.

Vitamin D is necessary for the proper formation of bones and teeth. Its absence from the diet gives rise to *rickets,* a complaint which is characterized by softness and deformity of the bones and defective formation of the teeth. Rickets is described more fully in Chapter 16.

Vitamin E.—Recently, attention has been paid to another vitamin, vitamin E. It occurs in lettuce leaves, eggs, meat, milk and various other foods. If this vitamin is absent from the diet of female rats they fail to have young, although otherwise healthy. It is not certain if the same is true of human beings or other animals.

Vitamins are required in the diet in only small amounts as they do not yield energy to the body. Since they tend to be destroyed by cooking it is as well, in planning a diet, to assume that it contains no vitamins and to add vitamin foods specifically. Thus butter will supply vitamins A and D ; brown bread or marmite will supply vitamin B ; while vitamin C may be obtained from fresh fruit and salads. Milk is useful in supplying all the vitamins with the possible exception of C.

Mineral Salts.—The diet constituents already described are all derived from living things, either animals or plants. To complete the diet it is necessary to include certain substances of lifeless or mineral origin. These are known to chemists as salts of various kinds, the most familiar being common salt.

Common salt (Sodium chloride).—This is a constituent of most of the body fluids. The blood plasma, the lymph, the tears and many other body fluids are largely salt water. Common salt is found in animal flesh, milk, and is added to other foods during cooking and preparation for the table.

Iron.—Iron forms part of hæmoglobin, the colouring matter of the blood which enables the red corpuscles to act as carriers of oxygen. Iron is obtained from meat, liver, egg yolk and some green vegetables, particularly spinach.

Lime (Calcium).—This is necessary for the formation of bones and teeth. Lime is found in milk and leafy vegetables, but cannot be used by the body unless vitamin D is also present in the diet.

Iodine.—This is the chief constituent of the hormone of the thyroid gland. It is obtained from fish and also from the drinking water of most districts. In some places far removed from the sea (such as Switzerland), the water is deficient in iodine and this substance has to be deliberately added by those responsible for the water supply.

A number of other mineral salts are necessary in the diet but they are not of sufficient importance to deserve special mention.

CHAPTER 14

BEVERAGES

FROM the point of view of hygiene, the two most important beverages are water and milk. In addition to these most races of human beings make use of artificial drinks such as tea, coffee and various alcoholic liquors.

WATER

Water is a normal constituent of the body, accounting for about 70 per cent. of the body weight. It is needed for three purposes. First, it forms the basis of the body fluids, such as the plasma of the blood, the lymph and the various digestive juices. Secondly, water is required for the elimination of waste products : the excretory liquids (urine and sweat) consist of over 90 per cent. of water, with solid matter dissolved in it. The third use of water in a diet is to supply the body with mineral salts, since drinking-water usually contains a variety of these. Most civilized people drink too little water. Two or three pints a day is a desirable amount, but it should be drunk between meals rather than with food, in order to avoid diluting the digestive juices. There is no great harm in taking part of the daily water allowance in the form of weak tea, although plain water is undoubtedly better for health and, moreover, tea is rarely available apart from meals. If more water is taken in than the body actually needs, it does no harm, since use is made of it in two ways. Part of it is excreted in the form of urine, thereby ridding the body of waste products. The remaining excess passes through the alimentary canal, without being absorbed, and accumulates in the large intestine and rectum. It thus adds bulk to the

bowel contents and forms a stimulation to muscular contraction which is valuable in preventing constipation.

Milk

Food Value of Milk.—The composition of cow's milk is shown in Table IX, and it will be seen that it contains all the necessary ingredients for a proper diet. The milk

TABLE IX.—The Approximate Composition of Cow's Milk

Protein	3·5 per cent.
Fat .	3·5 ,,
Carbohydrate	4·5 ,,
Mineral salts	0·7
Water	87·3 ,,
Vitamins .	A, B, C, D, E

(Milk is liable to be deficient in vitamin C.)

of any species of animal is, indeed, perfect food for the young of that particular species. This must obviously be the case, since young animals live exclusively upon milk in the early months of life. Cow's milk is very useful in human diet, but human beings cannot live upon this alone, since the proteins, fats and carbohydrates are not present in the proper proportions for human beings and, in any case, the nutritious ingredients of the milk are much diluted by the high percentage of water which is also present. It would be necessary to drink a gallon of milk per day to get the 3000 calories which an adult man requires from his diet. Hence milk can only form part of a diet, but it is an important part in the case of children.

The value of milk is illustrated by the following experiment. Some boys at an industrial school were divided into a number of groups, the members of each group being approximately of the same age, height and weight. All the boys received the ordinary diet of the institution, with an addition, in the case of each group, as shown in the Table :—

Group.

1 An extra pint of milk daily.
2 Water cress (Vitamin C and iron).
3 Biscuits (carbohydrate).
4 Dried casein (protein from milk).
5 Butter (fat and vitamins A and D).
6 Margarine (fat without vitamins).
7 No addition (control group).

After some months it was found that some of these groups had received distinct benefit from the additions to their diet and that, generally speaking, those who had received the extra ration of milk had shown better gain in weight and height and greater freedom from minor ailments than any of the others.

Milk in Schools.—It is becoming increasingly common for Education Authorities to provide milk for school-children, usually at a small charge, or free in necessitous cases. A pint of milk daily may be looked upon as an ideal for a growing child, but a third of a pint is the more usual quantity supplied in school. This may be drunk during the morning recess, and a useful method of serving it is to supply each child with a drinking straw and a small bottle of milk closed by a cardboard disc. The advantages of this method are that the milk is kept clean up to the time of consumption, the washing up of cups or mugs is obviated, while the use of the straw ensures slow drinking.

Dangers of Milk.—Although milk is an excellent article of diet, it is also a breeding ground for germs (especially those which cause tuberculosis and scarlet fever) since it supplies the nourishment which they, like other living things, require. The type of tuberculosis caught from milk commonly leads to disease of lymphatic glands and joints. Scarlet fever is characterized by a rash on the surface of the body, accompanied by a sore throat and high temperature, while later, diseases of the heart, kidney or ear may make their appearance. Both these diseases are discussed in a later chapter.

Graded Milk.—Boiling milk kills all the germs in it, but at the same time destroys the vitamins and renders

both the protein and fat less digestible. Therefore it is better to have raw milk produced under clean and hygienic conditions, so that it may safely be drunk unboiled. By an Order of the Minister of Health, milk is graded in different categories and each grade of milk must be produced in conditions of cleanliness which are laid down in the Order.

Tuberculin Tested Milk.—This is milk from cows which are regularly examined by a veterinary surgeon and which are specifically tested to ascertain their freedom from tuberculosis (***tuberculin test***). The milk must be bottled on licensed premises and every bottle must be suitably sealed, the seal or cap bearing the address of the bottling establishment and the words " Tuberculin Tested Milk." The milk must not contain more than a certain limited number of bacteria per cubic centimetre and, of course, none of these may be definite disease germs. If the milk is actually bottled on the farm, it may be labelled " Tuberculin Tested Milk (Certified)." If it is submitted to the process of pasteurization, described later, it must be labelled " Tuberculin Tested Milk (Pasteurized)," and, apart from this process, tuberculin tested milk may not be heated before being sold to the consumer.

Accredited Milk.—Accredited milk has not the same high standard of purity as tuberculin tested milk, although the name suggests that it is milk of exceptional quality. The cows from which it is derived are examined to see that they are free from disease, but they are not submitted to a specific test for tuberculosis. Regulations similar to those already described govern the bottling and sale of this milk and the caps of the bottles must bear the words " Accredited Milk."

It will be seen that much trouble and expense is necessary for the production of the better qualities of milk owing to the care which must be taken of the cows, the frequent testing and veterinary inspections, the scrupulous cleaning of cowsheds and the number of official inspectors who must continually supervise the processes to see that

all the regulations are carried out. In consequence, these milks tend to be dear.

Pasteurised Milk.—The process of pasteurization is named after the French bacteriologist Pasteur. In this process the milk is heated (not boiled) to a temperature of 145° F., kept at that temperature for half an hour and then quickly cooled. This kills almost all harmful germs and does not seriously impair the food value of the milk since boiling is avoided. The method is a very practical compromise between an expensive grade of raw milk and ordinary raw milk, since milk of any quality can be used, no matter how it was produced, as it will be purified by pasteurization at a central depot. The retail price of the milk is therefore not increased and this, together with its reasonable standard of bacteriological purity and its unimpaired food value, makes it very suitable for school children.

In addition to these recognized grades there is, of course, ordinary milk, which has not to conform to any particular standard of cleanliness. It is important to realize that the mere fact that milk is sold in a capped bottle is no guarantee of purity. The graded milks must bear the name of the grade on the cap.

Coffee

A cup of coffee consists, for the most part, of water, and so forms a convenient way of taking this fluid. But coffee contains about 1 per cent. of a drug known as *caffeine*. This drug acts upon the nerve cells and stirs them into activity when they would otherwise be fatigued. Thus a man who has to sit up at night and study may find that he is better able to remain awake if he drinks strong coffee. When the effect of the caffeine wears off he will, of course, feel all the more fatigued since he has really been flogging his tired nerve-cells long after he ought to have given them rest. Obviously coffee has its uses as a stimulant, but is not hygienically necessary, and is not to be recommended for children since they should have no need of artificial stimulation.

Tea

The drinking of tea also forms a convenient way of taking in fluid, but suffers from the same disadvantages as coffee since tea also contains caffeine (usually termed *theine* when extracted from the tea leaves). This substance is commonly present in the leaves to the extent of 2 or 3 per cent., but an actual cup of tea contains only about as much as a cup of coffee. It is interesting to notice that many people will not drink coffee at bedtime in case the caffeine in it keeps them awake, but they will cheerfully drink several cups of tea (and sleep quite soundly) as they are not aware that tea contains the same drug. This shows that the influence of the mind may sometimes be greater than that of a drug. In addition to caffeine or theine, tea contains from 6 to 12 per cent. of a substance known as *tannin* or *tannic acid*. This substance has the property of hardening proteins and is used by tanners in converting the hides of animals into leather. When strong, black tea is drunk (especially if it has been "stewing" for some time) the tannin in the tea has a tendency to harden the lining of the stomach, a process which in time leads to indigestion. For the same reason strong tea should not be taken with a meal containing meat, as the protein in the meat may be hardened and rendered indigestible by the tannin. The "meat tea" which is so popular in the North of England is therefore not an ideal form of meal.

Cocoa

As in the case of coffee and tea, drinking cocoa forms a way of taking fluid into the body. It contains only a small amount of drugs like caffeine and, unlike both coffee and tea, it has definite food value since it contains about 30 per cent. of fat and 15 per cent. of protein. Moreover, in the manufacture of cocoa starch is usually added so that the final product contains carbohydrate as well as protein and fat—though these foodstuffs are not present in ideal proportions. Cocoa is therefore a useful and hygienically sound article of diet.

Alcohol

A great deal of controversy centres around the question of drinking alcoholic beverages and many aspects of this question are simply matters of personal opinion. The present discussion of alcohol will be confined to the physiological effects of this substance, which are matters of fact proven by experiment and observation. The action of alcohol upon the human body will be more readily understood if it is borne in mind that its effects are similar to those of the well-known anæsthetics chloroform and ether. Indeed a mixture of alcohol with these two substances (A.C.E. mixture) is perhaps the most commonly employed anæsthetic in hospitals. Although alcohol is the most important constituent of wines and spirits, it should be remembered that these beverages also contain colouring matter and flavouring agents so that to speak of a person's "drinking alcohol" is as much a misstatement as to speak of a tea drinker's "drinking tannin." Table X shows the

TABLE X.—The Alcohol Content of some Beverages

Spirits (high alcohol content)	
Whisky .	50-60 per cent. by volume.
Rum .	50-60 ,, ,, ,,
Wines (medium alcohol content)	
Port . . .	20-30
Champagne	12
Claret .	10
Beers, etc. (low alcohol content)	
Cider	3-8
Beer	2-7

amount of alcohol contained in some beverages and indicates that in many cases a large proportion of the drink is water. It should be noticed that beer (often the subject of heated discussion) contains very little alcohol, while cider (widely regarded as a teetotal drink) may sometimes contain more than beer.

Action of Alcohol on the Stomach.—Alcohol has a great attraction for water, and if a vessel of strong alcohol is left uncovered for some hours in a room it will be found that it has absorbed water from the air, becoming diluted in the process. Consequently when any strongly alcoholic beverage (such as brandy) is drunk it extracts water from the cells lining the gullet and stomach, a minor injury to these parts which is appreciated mentally as a sensation of warmth. This extraction of water from the alimentary canal is liable to increase the thirst of a person who has drunk an alcoholic liquor with a view to quenching his thirst. If such an assault upon the stomach be often repeated, the lining of that organ tends to become permanently hardened and so indigestion may result. Confirmed spirit drinkers may suffer from indigestion of this type to such an extent that they become definitely undernourished and, in consequence, thin.

Food Value of Alcohol.—Apart from this local effect upon the stomach, alcohol is readily absorbed through the stomach wall and passes into the blood stream, not requiring to undergo any process of digestion. Once in the blood stream alcohol is readily oxidized and so yields energy to the body. Since it is absorbed and oxidized rapidly its energy is available within a very short time of swallowing it. Therefore, the body (when it has the opportunity) uses alcohol in preference to other foodstuffs, especially preferring it to fats which are difficult to digest. In consequence of this, habitual beer drinkers (not taking alcohol in a form sufficiently concentrated to cause indigestion) have a tendency to become stout as the alcohol is being used to provide energy in place of fat which, therefore, accumulates beneath the skin. The rest of the alcohol, which is not oxidized to provide energy, circulates round the body in the blood and produces a variety of effects.

Effect on Temperature.—When alcohol reaches the minute capillaries of the skin, it causes them to dilate and become wider. As a result the skin capillaries accommodate more blood and the surface of the body appears flushed.

The nerve endings in the skin, being surrounded by an excess of warm blood, convey to the individual concerned a comfortable feeling of warmth and so it is a common practice in cold weather to drink a small quantity of spirits "to keep out the cold." This feeling of warmth is deceptive, for it is obvious that with an increase of blood in the skin, the body tends to lose heat by radiation, so that there is a greater liability to catch cold. Arctic explorers have found that when men leave the ship to traverse the icefields, they are much more liable to frostbite if they have had an allowance of rum.

Action of Alcohol on Internal Organs.—Alcohol is a protoplasmic poison and so the cells of which the body is composed are all liable to be affected by it. Liver and kidney cells are particularly susceptible to alcohol and inflammation of these organs is a common sequel to intemperance. The activity of muscle cells is also impaired and they have an increased liability to fatigue. It has been repeatedly shown that where two groups of workmen are each given the same task to perform (such as excavating a trench), if alcohol is administered to those of one group, they tire before the other group.

Effect of Alcohol on Reflex Actions.—In the nervous system the synapses are affected and offer an increased resistance to the passage of nerve impulses. This causes reflex actions, both simple and conditioned, to be carried out less rapidly. The social effects of delayed reflex activity may be of considerable importance, as, for example, where the driver of a motor-car fails to avoid an accident due to delay of nerve impulses at the synapses of his spinal cord.

Action on the Brain.—The most important effects of alcohol upon the human body are those which it exercises upon the brain. The functions of this organ are attacked in order from above downwards. The highest psychical activities of the cerebrum are first affected, then lower, more primitive activities and, finally, the vital functions of

the medulla are depressed. It is here that the action of alcohol most closely resembles that of chloroform and ether. When the cerebrum is affected, such mental activities as inhibition, self-control and self-criticism are blunted. At this stage a man may make an after-dinner speech with less nervousness than would be the case if he were not under the influence of alcohol. It is popularly supposed that such a performance is the result of mental stimulation, but this is not the case as the apparent stimulation is due to dulling of the power of self-criticism which previously made the speaker unduly self-conscious. When the cerebrum is affected by a considerable quantity of alcohol the emotions get out of control, the individual laughing and crying in an unrestrained manner. A similar effect is often seen when a person is being anæsthetized for an operation. A still greater intake of alcohol may lead to a complete loss of all self-restraint and anti-social behaviour may result, the intoxicated person becoming noisy and violent. This corresponds to the stage of struggling through which an anæsthetized person passes before becoming entirely unconscious.

Larger doses of alcohol affect the balancing of the body (in which the cerebellum plays a part) and the control of the muscles generally. A drunken man reels and staggers when he walks and is generally incapable of performing a delicate action such as writing with a pen or introducing a key into a keyhole.

If intoxication has proceeded to the stage described, then usually the individual loses the power to pour the contents of a bottle into a glass and so no further effects are seen. If, however, still more alcohol is administered, the medulla may be affected. This part of the brain controls the beating of the heart and the movements of respiration and death may result from interference with its activities. In extreme cases of drunkenness, a person may lose consciousness, exactly as when chloroform or ether are administered.

Chronic Alcoholism.—The foregoing remarks apply to fairly large quantities of alcohol taken over a short period,

If smaller quantities are taken, but are repeated frequently and over a long period of time, a condition known as chronic alcoholism results. The principal features of this state are general physical and mental degeneration and increased liability to succumb to the attacks of germs. This is well exemplified in the case of pneumonia, a disease which is nearly always fatal when it attacks an immoderate drinker.

Temperance.—The effects of alcohol, especially upon the nervous system, give this substance considerable social importance. This aspect is considered in Chapter 35, under the heading of Temperance Teaching.

CHAPTER 15

THE FEEDING OF SCHOOL CHILDREN

FROM what has been said in previous chapters, it will be apparent that certain matters must receive attention in planning a complete diet. These are as follows:—

Essentials of a Diet.

1. It must contain suitable amounts of protein, fat and carbohydrate.
2. All the vitamins should be present.
3. There should be an adequate supply of the various mineral salts.
4. There should be a sufficient intake of fluid.
5. The food should be of a readily digestible nature and should not be rendered indigestible by improper cooking.
6. The food should be presented in a reasonably attractive manner. Food which is ill-prepared and badly served may not be appetizing and so is not so well digested.

Composition of Common Foods.—It is not usually practicable to calculate the calorie value of the food which is served at a meal. Therefore, it is useful to bear in mind the approximate composition of different foodstuffs in order to devise a meal which is reasonably well balanced. The composition of some common foods is shown in Fig. 73. It will be seen that most natural foods contain a high percentage of water. Some methods of cooking lead to the removal of some of the water, while other methods add more water to the food. Generally speaking, the animal foods are the best sources of protein. Amongst the vegetables,

those of the leguminous group (peas, beans and lentils) are richest in protein, but their protein is not so useful to a

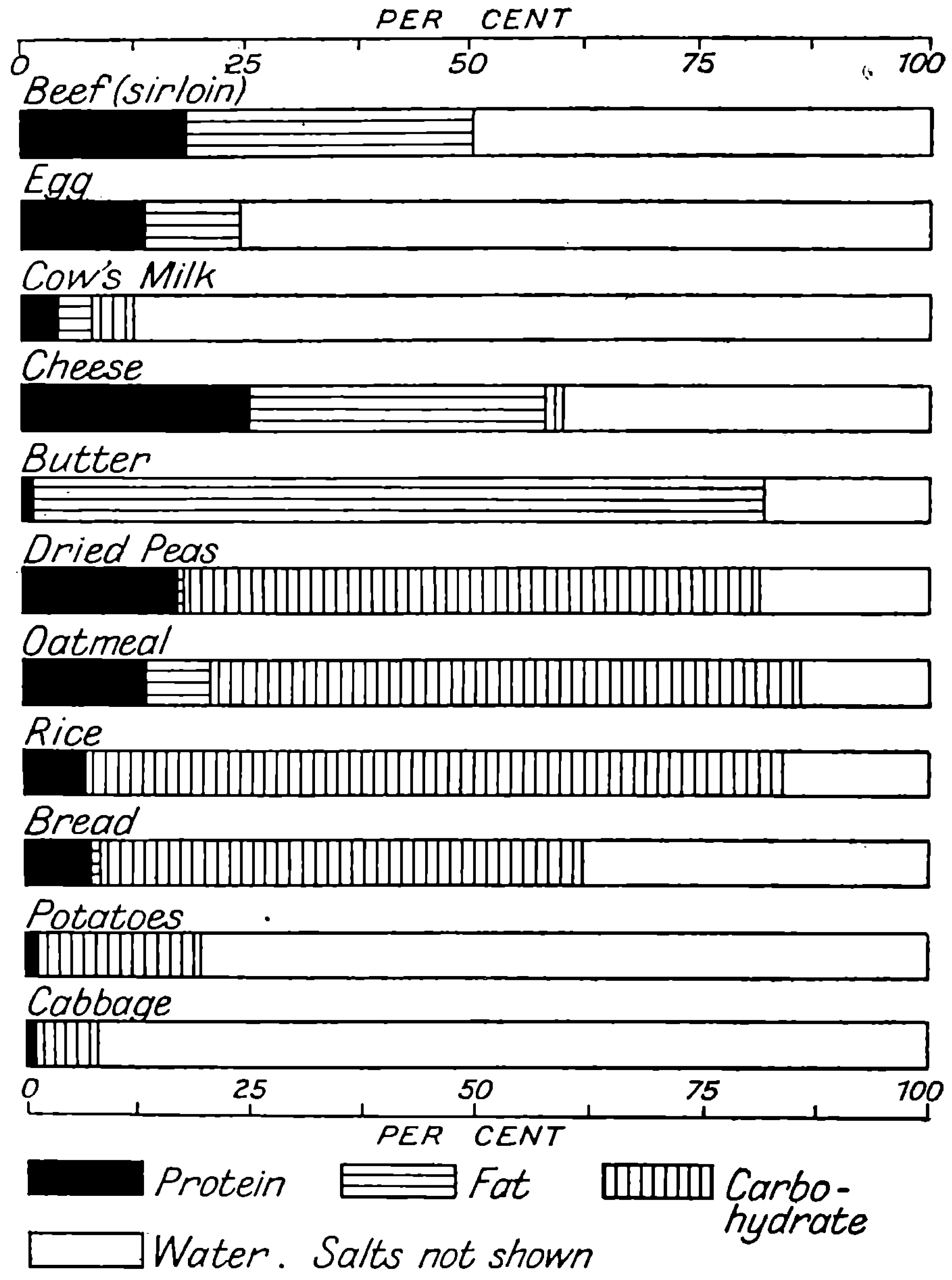


FIG. 73.—The composition of some common foods.

human being as that derived from animal foods. The cereals contain a great deal of starch, but most of the common, dinner-time vegetables contain relatively little

nourishment and a great deal of water. Nevertheless the diet should contain such vegetables as cabbage and sprouts because of the vitamins which they contain, and also because the fibrous parts of the leaves form roughage which is valuable in diminishing liability to constipation.

Typical Diet for a Day.—So far we have considered food only from the chemical aspect and measured it in metric units. It will, perhaps, be useful to consider a day's diet expressed in terms of ordinary foods and familiar measures. Table XI sets out a diet which would yield

TABLE XI.—A Typical Diet for a Day (Yielding about 3000 Calories)

Bread	15 ounces.
Meat	6
Milk	20
Butter .	$\frac{2}{3}$
Potatoes	10
Jam	2
Cereal	$2\frac{2}{3}$
Sugar	2
Bacon	2 ,,
Salt	ad lib.
Fruit . . .	
Liquid (water, tea, etc.)	

about three thousand calories of energy and so would be suitable for an average man. It would require modification for a woman or a child and the ingredients could, of course, be varied. The meat is supposed to be an ordinary cut of beef, with lean and fat in average proportions. The butter would be used both in cooking and spread on bread. A somewhat smaller amount is allowed than that usually taken by most people. The cereal might be partly a breakfast food and partly rice, which, with some of the milk, could be used as a pudding. Few people take the quantity of milk stated in the Table.

Criteria of Adequate Diet.—The weight of an individual forms a useful index as to the adequacy of the diet. In the case of an adult, the weight ought to remain

fairly constant. Any marked increase or decrease generally indicates either the presence of some disease or insufficient (or too much) food. A child ought not to maintain a constant weight, but should increase according to the normal standards for the sex and age. Failure to increase in weight in a normal manner again indicates either illness or an improper diet. It is a wise practice to weigh children at regular intervals.

TABLE XI*a*.—HEIGHT AND WEIGHT OF CHILDREN AT VARIOUS AGES

Age.	*Boys.*		*Girls.*	
	Height inches.	*Weight lbs.*	*Height inches.*	*Weight lbs.*
4	39	36	37	34
5	41	40	40	38
6	43	44	41	42
7	45	48	43	46
8	48	53	46	50
9	49	58	48	54
10	51	64	50	59
11	53	70	52	64
12	54	76	55	72
13	56	80	57	82
14	58	86	59	92
15	61	95	60	102
16	63	110	61	109
17	64	126	62	114
18	65	134	63	118

Meals for School Children.—Meals may be provided by Education Authorities for two reasons. If children cannot readily get a mid-day meal at home, or live too far from the school for it to be practicable for them to go home at midday, then meals may be provided at the school as a matter of convenience. In the case of poor and under-nourished children, school meals may be provided on grounds of necessity. Parents are usually required to pay

for the meals which their children receive, but in certain necessitous cases meals may be provided free of charge. The usual school meal (apart from special and residential schools) is a midday dinner, but in some places breakfast is also provided. This generally consists of such simple things as bread and dripping and cocoa. Milk, supplied at the morning break, may also be considered as part of the usual school feeding arrangements.

TABLE XII.—Dietetic Value of some Foods

	Protein.	*Fat.*	*Carbohydrate.*
	per cent.	per cent.	per cent.
Porridge	12	9	70
Milk .	3·5	3·5	4·5
Cheese	26	35	—
Bread	7	—	47
Butter	—	83	—
Herring	12	11	—
Haricot beans	18	—	65
Dried peas .	20	—	57
Lentils	20	—	64
Eggs .	11	10	—
Apples	—	—	10
Bananas	—	—	14

In planning meals for school children, due economy must be observed in choosing the food. It is possible to have a reasonably cheap diet which is also nutritious. Table XII sets out some cheap foods and indicates their nutritive values. Such commodities as eggs vary in price according to the season of the year and this is a point which must be borne in mind. The greatest difficulty is experienced in selecting protein foods, as these are apt to be expensive. Peas, beans and lentils are useful here, since they contain

a good deal of protein and are, at the same time, cheap. Some kinds of fish are good sources of protein, and are also cheaper than meat. The herring is a particularly rich source of protein and may be introduced into the diet to supply the necessary minimum of animal protein, eked out by vegetable protein from the leguminous group of vegetables.

Monotony in the diet should be avoided as far as possible, as uninteresting food does not excite the secretion of digestive juices to a satisfactory extent. When catering for

TABLE XIII.—Menus for a Week in a School Feeding Scheme

Monday.	Minced beef.
	Mixed vegetables.
	Sultana pudding and custard.
Tuesday.	Meat and potato pie.
	Lentil stew.
	Rice pudding.
Wednesday.	Sausages.
	Potatoes.
	Greens.
	Suet pudding and treacle sauce.
Thursday.	Meat and potato pie.
	Lentil stew.
	Sago pudding.
Friday.	Fish pie.
	White sauce with marrowfats.
	Currant pudding and custard.
Saturday.	Stew with dumplings.
	Potatoes.
	Ground rice pudding.

Brown and white bread supplied at each meal.

large numbers of children it is possible to secure a reasonable degree of variety without excessive cost. Table XIII shows menus for a week in a school feeding scheme employed in Leeds. The daily cost of the food averaged 1·48 pence per head and the total cost of each meal (allowing for cooks' wages, transport of food from a central kitchen, etc.) was 3·22 pence per head.

Premises for School Meals.—The actual system of organizing school meals varies in different districts. The schemes commonly employed are :—

1. Dining hall, kitchen, etc., at the school.
2. Central kitchen for the distribution of meals to schools.
3. Cookery centre with dining hall which serves the schools of a district.
4. Canteen where children buy meals.
5. The use of a public restaurant.

Each of these schemes has certain advantages and also disadvantages attached to it. These will be described in detail.

Dining hall at school.—If a school is equipped with its own dining hall, kitchen and other offices, there is the great advantage that teachers and children are already on the premises at dinner time without having to make any journey, thus punctuality is assured. It is also easier to maintain discipline when the children are in their own school in the charge of their usual teachers. Moreover, it is possible for the children to rest after the meal when otherwise they might have to hurry back to school.

It is, however, expensive to build and equip separate kitchens at each school. Catering and cooking are also more costly when done on a relatively small scale at many separate schools.

Central kitchen.—The central kitchen is a place where meals are cooked and afterwards sent out to different schools, or to dining halls, where the meals are eaten. Catering and cooking in bulk for all the schools of the district is much more economical than in the last scheme where each school deals with its own meals.

The chief disadvantage about this system is the difficulty of distributing the food satisfactorily. It is not always easy to ensure that the meal is hot when it finally arrives at the school, unless expensive containers are employed. Motor transport has, however, diminished the difficulty of rapid distribution to a considerable extent.

Cookery centre.—In order to overcome the difficulties attached to the central kitchen while retaining some of its advantages, the cookery centre may be utilized. Here

food is cooked and served in a dining hall to which children are brought from a number of surrounding schools. There is the same economy of catering and cooking in bulk that was mentioned in connection with the central kitchen without the problem of ensuring satisfactory distribution.

The use of a cookery centre raises some fresh disadvantages. As the children have to travel there from their own schools and then back again after the meal, it is not possible for them to rest after eating. Moreover, they are exposed to bad weather at some seasons of the year and to the dangers of crowded streets and traffic. The large crowd congregated at the centre makes it more difficult to maintain discipline, especially if the children have come from different schools and are not all known personally to the teachers.

Canteen.—The canteen system provides food which is purchased by the children at school. It is useful in rural districts where the provision of meals is on grounds of convenience, but is no use where meals are provided on account of economic necessity.

Restaurant.—When no other system is possible, children may be taken for meals to a public restaurant. This should only be done as a last resort, since it offers no advantages over the schemes already described and has a number of disadvantages. The food can rarely be obtained so cheaply, as the restaurant proprietor must make a profit from the meal where the Education Authority would be content to cover the bare cost. Again, there is the difficulty of maintaining satisfactory discipline unless a private room is used, which further increases the expense.

Conduct of Meals.—School meals may have general cultural and educational value in addition to providing nourishment. Older girls may participate in the catering and preparation of the meal as part of their instruction in domestic economy. During the meal reasonably civilized behaviour must be insisted upon, and snatching, gobbling and unseemly conduct prevented. It is often

advantageous for the older children to assist in supervising and waiting on the younger ones, taking their own meal afterwards. If possible it is desirable for a short rest to be taken before eating: no violent games or running about being indulged in before coming to the table. This time may be profitably employed in washing the hands and achieving general tidiness. Conversation should not be prohibited during the meal: the school dinner need not be a solemn penance. All faddiness should be discouraged, and an over fastidious child should be encouraged to eat and like what the others obviously enjoy. It is also desirable to insist upon rest after the meal while digestion is commencing, instead of permitting the children to run about and play vigorously.

Law in Relation to School Feeding.—Before the year 1906, school meals, if provided at all, were supplied by charitable organizations. The Education (Provision of Meals) Act of 1906 empowered Local Authorities to assist these voluntary efforts. An Act of 1914 gave grants to assist the Local Authorities and also enabled them to provide meals in certain circumstances during the holidays and times when the schools are normally closed. The Education Act of 1921 codified these earlier Laws.

CHAPTER 16

MALNUTRITION

THE term *malnutrition* means, simply, improper nutrition and includes not merely undernourishment, but a number of other conditions. Malnutrition may be caused or aggravated by two groups of factors. First there may be something amiss with a child's general environment which interferes with his nourishment, no matter how perfect the diet may be. Secondly, there may be something wrong with the diet itself, and this will obviously impair nourishment, even in an environment which is otherwise satisfactory. In an actual case of malnutrition, it is usual to find both sets of factors operating.

General Factors causing Malnutrition. ***Neglect at home.***—A child may come from a home where there is no lack of money to buy food and where food may actually be plentiful. If, however, the parents are of a casual and easy-going nature they may not trouble to prepare meals at regular times and may not bother to see that the child is regularly fed. In such a case undernourishment is likely to occur.

Bad hygienic surroundings.—A child may suffer from malnutrition as a result of lack of fresh air, sunshine and exercise. There may be overcrowding and bad ventilation in the home, or these conditions may obtain at the school, especially if this is an old building in a densely populated district.

Overwork and lack of sleep.—A diet which is sufficient to provide for the activities of a normal day may prove insufficient if a child has to do extra work, as in following

some employment after school hours. Apart from extra work, activities in excess of those which the diet can support may occur when a child is not sent to bed at a reasonable hour, and so suffers from lack of sleep with corresponding increase in the length of the active day.

Ill-health.—The presence of disease commonly produces malnutrition, since the body is unable to deal with the food even when this is provided in sufficient quantity and is of proper quality. A short illness may not be serious in this respect, as nutrition becomes normal after the return to health. Sometimes, however, even a short illness may leave a lasting mark in the form of a flaw in a tooth or bone, or some part of the body which was being formed during the period of illness. A long-continued, debilitating illness is still more likely to interfere with nourishment.

Dietetic Factors causing Malnutrition. *Excess of food.*—It is commonly overlooked that overeating may be, in its way, as bad as undereating. When too much food is habitually taken, the excess is stored in the body in the form of fat. The individual then has additional weight to carry about and so must put forth additional effort for his everyday activities. The fat is not only stored beneath the skin (giving rise to obvious obesity) but is also deposited in some of the internal organs, notably in the heart. Some of the heart muscle is replaced by fat and this renders the organ much less efficient. Excess of food intake also leads to the excessive formation of waste products from the utilization of this food, and so an increased burden is thrown upon the excretory organs. The greatest burden, perhaps, falls upon the digestive system, as it has to digest abnormal quantities of food, and indigestion may arise in consequence.

Meals at improper intervals.—If meals are taken at very short intervals, then, in the course of a day, too much food enters the body and so the effects of overeating are again seen. If food is taken too seldom the total daily intake may be inadequate and partial starvation results.

This will be discussed later. If meals are taken irregularly, sometimes at short intervals and sometimes at long, the alimentary canal is unable to form regular habits of rest and work. This frequently leads to indigestion and so to malnutrition.

Improper food.—Some foods are more difficult to digest than others. If these are taken occasionally in a well mixed diet no harm results, but if they constitute the bulk of the diet, then nutrition may be impaired. Table XIV shows the length of time for which various foods

TABLE XIV.—DIGESTIBILITY OF FOODS

	Number of hours retained in the stomach for digestion.
Rice	1
Tripe	1
Milk	2
Potatoes	2
Spinach . . .	2
Eggs (raw or soft-boiled)	2
Bread	2
Salad	2
Oysters .	3
Beef steak	3
Ham .	3
White fish	3
Pork	4
Salt pork . .	5
Eggs (hard-boiled) .	5
Ordinary mixed dinner	. 4-5

This table is only approximately correct, as the time for digestion in the stomach is influenced by many factors, such as the quantity of food taken and the presence of other foods.

remain in the stomach undergoing digestion. Very fatty food like pork requires a long time, as do foods in which the protein has been rendered hard by some type of preserving or by boiling, such as salt pork and hard-boiled eggs. Food which is not naturally indigestible may be made so by certain methods of cooking. Frying, which impregnates the food with fat, naturally diminishes the digestibility.

Some fried food is permissible in a diet, but malnutrition may occur when nearly all the diet comes from the frying pan, as is not uncommon in some homes.

Wrong food for age or mode of life.—It has been shown in a previous chapter that dietetic requirements vary according to age. A diet which is sufficient for a baby may be quite inadequate for an older child. Moreover, food which is not harmful to an adult may be beyond the powers of a less mature digestive system. To prevent malnutrition, therefore, the food must be suitable in quality and quantity for the age of the individual. The mode of life also affects the dietetic requirements. For example, a manual worker needs more energy-producing food than a sedentary worker. A child who lives on a farm may work much more vigorously out of school hours than a city child, and so will use up more energy. Furthermore, the country child has more opportunity for exposure to fresh air and sunshine, and so will not need vitamin D, for example, so urgently from his diet as a child living in a town.

Insufficient food.—The most common form of malnutrition is undernourishment from insufficient food. There may be a deficiency in total quantity, or the diet may be lacking in some important constituent such as one of the vitamins. In the first case there is partial starvation with lack of growth and lack of energy. In the second there will be the definite symptoms associated with deficiency of the particular constituent which is missing. The term malnutrition, as commonly employed, generally refers to lack of food rather than to any of the other forms that have been mentioned.

Chief Causes of Malnutrition.—The causes of malnutrition which have been described are not all equally common. Usually when a child is ill-nourished, the following three factors are found to have been operating :—

1. Lack of sleep.
2. Ill-health.
3. Lack of an adequate quantity of wholesome food.

Signs of Undernourishment. *Small size.*—If the diet is insufficient growth is retarded and even the repair of worn out tissues may be imperfect. A child therefore tends to be thin and below the normal weight. He may also be less than the proper height for his age. These signs are particularly likely to be present if the diet is deficient in protein as this is the material which provides for growth and for the repair of wear and tear.

Muscular weakness.—An inadequate diet does not permit the proper formation of strong muscles and does not supply sufficient energy for such muscles as are formed. An undernourished child may therefore appear muscularly weak and will also become easily tired after comparatively slight exertion.

Pallor.—Undernourishment is commonly accompanied by lack of hæmoglobin in the blood, a type of anæmia. Hæmoglobin is the material which gives the blood its characteristic red colour, and when this substance is deficient the individual tends to have pale cheeks and lips, parts which should normally be well coloured.

Mental apathy.—The mind generally suffers when the body is undernourished, the condition being characterized by lack of mental alertness which naturally retards a child's progress in school.

Rickets.—One variety of malnutrition presents fairly constant symptoms : it is looked upon as a definite disease and is called *rickets.*

Nature and causes.—Rickets is a condition in which the hard parts of the body, the bones and teeth, fail to grow perfectly and remain too soft. Several factors help to bring about this state of affairs. General poor hygiene plays a part, together with a defective diet. The rickety child is generally one who has had a diet containing an excess of carbohydrate and frequently a deficiency of calcium. These things are not in themselves sufficient to produce rickets : vitamin D must also be lacking in the diet. It is the deficiency of vitamin D, with consequent

inability to build up hard bone and tooth material which is the fundamental cause of this complaint. As vitamin D is found in fats of animal origin, which are fairly expensive foodstuffs, it is not surprising that the deficiency most commonly occurs in poor children living in bad hygienic surroundings, with a diet rich in such carbohydrate foods as bread and potatoes.

Symptoms.—Figs. 74 and 75 show children suffering from rickets. The undue softness of the bones has led to

FIG. 74.—A rickety child.

FIG. 75.—Spinal curvature due to rickets.

the development of certain deformities under the influence of the body weight. The lower limbs have to bear the greatest weight and they commonly yield, giving rise to bow-legs or knock-knees. The hip girdle may also be deformed as it transmits the weight of the trunk to the legs. Such pelvic deformity is particularly important in females as it may interfere with childbirth later in life. The abnormal curvature of the spine, shown in Fig. 75, is not only caused by the weight of the head and chest pushing the

soft bones out of position but is aggravated by habitual faulty posture in sitting and standing (see Chapter 19). The pull of muscles may also produce deformities of the soft bones. For this reason it is not uncommon to find a badly shaped chest owing to the continued action of the muscles between the ribs during breathing. Bones grow chiefly at their ends and, as the growth is disordered in rickets, the ends of the bones frequently show marked swelling. Such swellings are apparent at the wrist and ankle in Fig. 74. They are also found at the ends of the ribs where they join the breast bone, and bony protuberances may occur on the skull in the region of the forehead. Other symptoms of rickets are excessive sweating, particularly of the head, undue prominence of the abdomen (" pot-bellied " infants), and mental backwardness.

All these symptoms are most frequently seen within the first two years of life, as this is the common age for rickets. By the time the child comes to school the active phase of the disease is over, but there remain the deformity and stunting of the body together with mental dullness.

Methods of Dealing with Malnutrition.—An obvious way to prevent malnutrition is to remove the underlying causes as far as possible. The school can contribute to this by providing education in hygienic living with special reference, in the case of girls, to dietetics and cooking. The benefit which would result from such education would only be seen when the present generation of children became parents, and then only in the case of the more intelligent. As an immediate remedy for undernourishment school feeding is provided. It falls to the teacher to pick out those children who appear to be undernourished and to draw to them the attention of the School Medical Officer or School Nurse. The School Medical Officer eventually sees these children and decides whether they need treatment for some underlying illness or whether they would be benefited by receiving school meals.

PART III

HYGIENE OF CHILDREN

CHAPTER 17

GENERAL PERSONAL HYGIENE

THE previous sections of this book have been concerned chiefly with the general principles underlying the working of the body. In the present section these principles are applied to matters of practical hygiene and the knowledge already acquired will be utilized in these studies. A very important aspect of hygiene is that concerned with the cleanliness and care of the surface of the body. In Chapter 8 the structure and function of the skin were described and the desirability of maintaining the skin in a clean condition should now be apparent. If dirt, sebum and sweat are allowed to accumulate upon the skin, the resulting mixture makes the individual socially objectionable and interferes with the excretory function of the skin. Cleanliness not only involves a consideration of the body surface but also of the clothes which cover the body. Children have no natural instinct or desire for cleanliness and tidiness and need to be taught to value these things. Well-cared-for children receive instruction at home, probably not direct and obvious instruction but they are brought up to take certain hygienic standards as a matter of course. In the case of many poor and neglected children such home training is lacking and, if they are to be trained in cleanliness at all, the training must take place at school.

Training Children in Cleanliness.—Definite hygiene lessons, especially concerning the skin, may be of value in the case of older children. Such lessons provide a rational

basis for cleanliness, but hardly suffice in themselves to initiate new habits and new ways of living. To be effective, training in cleanliness should go on constantly and unobtrusively, particularly in the early years of school life. It is convenient to inspect the state of the hands and finger-nails before such a lesson as drawing or writing in which the hands are to be employed and when the need for clean hands will be obvious to the children. The general state of the clothing, tidiness of the hair and similar points should receive the teacher's attention at the beginning of school in the morning and afternoon. The condition of outdoor clothing can be supervised by some member of the staff making a regular tour of the cloakrooms. In addition to supervision of this type the personal example of the teacher and that elusive thing, the tone of the school, play important parts in bringing up children in clean habits. Young children in particular generally desire the approval of some admired person, such as the parent or teacher, and this person they tend to imitate. It behoves the teacher, therefore, standing continually as an example before the class, to take rather more than ordinary care about his or her personal appearance. Praise and blame in regard to matters of cleanliness should be distributed judiciously. A child who is clean merely because he fears blame and punishment is likely to fall into slacker ways when control is removed. A child who is praised excessively for being clean may become an objectionable little prig.

It is sometimes useful in hygiene, as in other matters, to harness the competitive spirit, awarding privileges for cleanliness and deprivations for dirtiness. A badge may be worn for a week by the cleanest child, or some symbol may be hung upon the wall to indicate the superior cleanliness of one team compared with the rest of the class. Turning cleanliness into a game in this way, however, must not be overdone so that the underlying aim becomes obscured, or so that offence is given to children and parents.

By the time a child reaches the senior school, dawning self-respect should be sufficient inducement to make him clean and tidy. Those who still fall short may have

pointed out to them the social advantages of maintaining a reasonable standard, and the better chance of obtaining employment which will result.

Washing.—If children are to form habits of cleanliness during their school life, proper facilities for washing must be provided and, if provided, should be used. Wash basins should be fitted in the proportion of at least one to twenty children and hot water should be available as well as cold. It is sometimes found that soap gets mislaid or is thrown about the cloakroom and to avoid this powdered or liquid soap may be provided in a suitable container, from which only a small quantity can be extracted at a time. Nail brushes are usually necessary to clean children's hands satisfactorily and to prevent abuse of these they may be attached to the wash basins by lengths of chain or screwed down, bristles uppermost, so that the hand may be rubbed upon the stationary brush instead of following the more usual procedure. It is more economical to provide roller towels, although this is not the most hygienic arrangement. The use of a common roller towel by successive children facilitates the spread of many diseases, and individual towels are much better from this point of view. Paper towels, which are destroyed after use, are available, but they are not entirely satisfactory. If roller towels are used, they should be changed as often as possible. The cloak-room should contain facilities for drinking as well as for washing. Cups and beakers are open to the same objections as roller towels, and the most suitable arrangement is a separate drinking fountain which projects a short column of water upwards. Drinking is thus possible without actually applying the mouth to any of the fittings.

Many children need to be taught how to wash (not to use the towel to wipe wet, but unwashed, hands, for example) and how to use cloak-rooms in a proper manner. They should empty the wash-basins after use and clean up any mess which may unavoidably have been made.

Bathing.—Bathing of the whole body is clearly desirable in order to maintain cleanliness. In the case of some

children bathing facilities at home are lacking and in other cases arrangements for a bath can only be made with difficulty. Nevertheless, children should be encouraged to take baths as frequently as possible and one hot bath per week should be regarded as the absolute minimum. In districts where home bathing is not practicable, arrangements may be made for children to have one or two weekly baths at school. A recently built school may have its own baths, or a bathing centre may be utilized to serve several schools in a district. The shower bath is the best type for schools as it obviates the filling and emptying of bath tubs which wastes time and, in the end, more water. About twenty showers may be arranged in a room over suitable draining channels. The showers should be in the centre rather than along the walls to enable the supervising teacher to walk all round the group of bathing children. Time may be economized if two sets of dressing-rooms are provided so that one group of children can be undressing while another group is dressing.

To be successful a bathing period must be carefully managed and all activities run to a time-table. Half an hour is the usual period allocated. Five minutes should be allowed for undressing, five minutes for bathing, and twenty minutes for drying and dressing. The period actually spent under the shower should be further subdivided so that each child has a specific task to perform at any given moment, thus leaving no time for the mischievous to cause trouble. One minute may be allowed for soaping and rubbing the body all over. One minute for rinsing with the water at a temperature at about 95° F., then a further three minutes during which the water is gradually cooled to about 65° F. The tap controlling the cooling should be out of reach of the children and under the care of the teacher or some other responsible person. It is very important that each child should be properly dried to prevent catching cold, as some parents are very prone to attribute all the child's ailments to the practice of school bathing, a practice which they view with suspicion. In the case of girls, the hair must be protected

by a suitable cap, unless a spray bath is used in which the water is not projected higher than the shoulder. For older girls, at least, separate dressing cubicles should be provided: separately screened showers are also desirable. The teacher must also see that each child has the proper complement of clothing upon its back and that no boy, for instance, goes home with his vest in his pocket, which would almost certainly prejudice his mother against the system of school bathing.

Bathing children at school regularly leads to certain benefits. The school is pleasanter for both children and staff and the health of the pupils tends to be improved. The practice also stimulates the children to be clean and usually leads to the parents' taking greater care to provide clean and properly repaired underclothing when they know that this is likely to be seen by the teacher and by their neighbours' children.

Swimming Baths.—Swimming baths are not primarily intended to be a means of cleansing the body although they do provide an incidental stimulus in this direction, since dirty children will obviously not be allowed to bathe. Even those children who are clean should take a preliminary foot or shower bath before entering the swimming pool, and the bladder should also be emptied as immersion in cold water is liable to lead to the reflex discharge of urine. A swimming bath should be lined by white tiles as it is quite possible for a child to sink unobserved against a background of dark green or blue tiles such as are not infrequently found lining older baths. The water should be at a temperature of about 70° F. and should be cleaned and disinfected frequently—continuously if possible. The remarks about proper drying and dressing which have already been made apply equally in the case of children using swimming baths.

Care of Hair, Finger Nails and Nose.—In addition to cleansing the surface of the body, proper personal hygiene requires attention to be paid to other matters. The hair should receive a due measure of regard, being frequently brushed and combed and, of course, washed at regular

intervals. The state of the hair of each member of the class should be observed by the teacher at the beginning of the day's work. Children should be required to keep their finger nails clean and trimmed. In some schools it is the practice to have scissors brought on a certain day each week and manicuring carried out under supervision. A running nose is an unpleasant and unhygienic thing, and every child should have a handkerchief or piece of rag and be taught to use it from the time it enters the Infants' Department.

Cleanliness of Clothing.—Cleanliness of clothing is necessary as well as cleanliness of the body itself. All clothing should be reasonably clean and tidy and in a satisfactory state of repair. Underwear, being worn next to the skin is particularly important. It is no use keeping the skin surface clean if dirty clothing is continually applied to it. The condition of underwear may be conveniently observed during a bathing period. There should be an adequate supply of buttons or other fastenings, preferably situated in front of the garments where the child can manipulate them itself. The unhealthy practice of sewing a child into its underwear for the winter is now a thing of the past, but it is not uncommon to find clothes supported by means of string, and this is likely to produce undue pressure upon those parts of the body which it surrounds. Underwear should be changed frequently, once a week at least. It has been found that after wearing clothes for one day upon a previously bathed body as many as 400,000 germs per square inch were present. After six days' wear, these had increased to 10,000,000 per square inch. In some walks of society, it is a common practice for people to sleep in the same underwear that they wear by day. This is bad because it submits the garments to excessive use and so soils them quickly. These same individuals are just the ones who change their underwear least frequently.

CHAPTER 18

WARMTH, CLOTHING AND FOOTWEAR

CLOTHING was discussed in the last chapter in as far as it affects the cleanliness of the body by being in contact with the skin. Clothing is worn for several reasons : from motives of modesty, as a form of personal decoration, and as a means of keeping warm. It is this last reason which concerns us here, as the skin needs assistance in maintaining the body heat in all regions of the world except the tropics.

Production of Body Heat.—The heat of the body is generated chiefly by the contraction of muscles. During vigorous exercise many muscles are contracting and so much heat is produced. Apart from definite exercise some muscles are always at work : the heart is continually beating and the chest muscles are always producing the movements of respiration. Some part of the alimentary canal is usually at work digesting food and this food is moved along within the alimentary canal by the action of muscles. The heat of muscular contraction is due to the oxidation of foodstuffs and so the production of body heat is ultimately dependent upon the diet.

Regulation of Body Heat.—It was explained in Chapter 8 that the temperature of the human body is usually considerably higher than that of the surrounding atmosphere. The importance of this fact was also pointed out. The body heat is regulated and maintained at this relatively high level by the skin, the layer of fat beneath the skin keeping the heat in. When an exceptional amount of heat is produced, as by muscular exercise, the capillaries of the skin become dilated. This brings more blood to the surface

of the body and the skin appears flushed, while heat is lost from the surface by radiation. The sweat glands also become more active and evaporation of sweat from the skin surface assists in cooling down the body.

Normal Temperature.—The temperature of the human body is fairly constant in health and does not ordinarily vary by more than 1° F. during the day. The average figure is 98·4° F. (about 37° C.) in men and a trifle higher in women and children. In most people the temperature is highest in the evening and lowest early in the morning, but there are many individual variations both in level and range of temperature. The temperature of the outside air varies in different parts of the world and at different seasons of the year. In England ordinary rooms of buildings are maintained at about 60° F. (16° C.). When the temperature begins to deviate from this figure people feel uncomfortable and light fires to get more heat, or open windows for coolness, as the case may be. There is thus a difference of over 30° F. between the body temperature and the average temperature of the surrounding air, and clothing is worn to help the skin to maintain this difference.

Heat Conduction.—To conserve the body warmth clothing should be made of material which is a poor conductor of heat. What is meant by heat conduction will be understood by considering the following example. If a room is at 60° F. all the objects in that room will be at the same temperature (apart from radiators, living creatures and other sources of heat). In spite of this some objects feel cold to the touch while others do not. A piece of metal, such as a poker, is a good conductor of heat and rapidly carries off heat from the hand that grasps it. A poker therefore feels cold. A piece of material, such as a tablecloth, is a poor conductor of heat. As it does not convey heat away from the hand it does not feel cold when handled, although it may be at the same temperature as the poker. Different materials vary in their heat-conductivity and stationary air is one of the worst conductors. In order to keep warm it is desirable to wrap the body in

still air and this may be done by wearing clothing which will hold a layer of air between itself and the skin.

Nature of Clothing. ***Texture.***—Wool, and fabrics containing a large proportion of wool, make for warmth because this material is a poor conductor of heat. Moreover woollen garments are so woven that they fit loosely, thus maintaining a layer of air between the garment and the body. Additional air is entangled in the meshes of a woollen garment as the actual strands of wool are not packed tightly against one another. Thin and closely woven fabrics such as cotton and linen have not got these air-entangling properties and so are not as valuable for keeping the body warm.

Absorption.—A certain amount of sweat is continually appearing on the surface even in the absence of vigorous exercise. The evaporation of this fluid leads to cooling of the body and so the clothing should absorb it, thus keeping the body dry. Not only should the clothing absorb moisture quickly, but it should be able to hold a fair quantity without actually appearing damp, and should allow the moisture to evaporate at a slow rate, so that an undue cooling effect is not produced. In this respect, wool is again good, while cotton and similar fabrics are not. Wool takes up moisture readily without becoming sodden and only allows slow evaporation to take place.

Although wool is desirable for its conduction and absorbent properties, many people find it unpleasant to wear. Furthermore, woollen garments are relatively expensive and are also liable to shrink. Two devices are used to overcome these disadvantages. Materials are made which contain a proportion of other substances to dilute the wool content and some cotton fabrics are specially treated and woven to imitate wool by the formation of air-holding spaces. Materials of this last type may be more expensive than wool although free from other disadvantages.

Colour.—The colour of clothes is largely a matter of personal fancy, but has some hygienic importance. Dark

clothes absorb heat from the sun more readily than light coloured clothes, and so should be worn in winter when warmth is needed. For this reason white or light-coloured garments may be worn in summer. The influence of colour may be demonstrated by taking two pieces of material, one black and the other white, but otherwise identical in texture, shape and size. If these are laid upon snow when the sun is shining it will be found that the snow melts quicker under the dark material than under the light, thus showing that the dark cloth has absorbed more heat. The influence of colour upon conductivity may, of course, be shown in more precise ways.

Faults in Children's Clothing.—Three faults are commonly seen in the clothing of school children and these must be briefly discussed.

Excessive clothing.—If too many clothes are worn, a child may be disinclined to run about and take exercise, partly because he feels no urge to create body warmth, and partly because his free movements are hampered. Boys are sometimes found wearing a jacket, jersey, waistcoat underneath, and shirt and vest below that, even during physical training lessons, when some clothes might have been profitably removed.

Scanty clothing.—Wearing too few clothes is obviously undesirable, especially in winter. Frequently the fault is not a deficiency in the total number of garments, but inequality in their distribution about the body. The trunk may be warmly wrapped up while the limbs, especially the legs, are left bare. This upsets the regulation of body heat, since the exposed skin is trying to keep heat in while the covered skin may be trying to lose heat.

Badly suspended clothing.—Clothes should nowhere be so tight as to constrict the body. Tight belts may interfere with breathing and tight garters may impede the circulation of blood in the legs. Clothing is best suspended from the shoulders, and stockings should be attached to a bodice which is so suspended. Where custom or convenience demands suspension from the waist, care should

be taken to avoid undue restriction of the abdominal movements.

Faults in Footwear.—Footwear, too, is commonly at fault in one or other of three particulars.

Too heavy.—Children readily grow out of their boots and shoes and equally readily wear them out by rough usage. For these reasons, parents are tempted to buy footwear a little too large and of particularly strong build. If these things are carried to excess, the footwear becomes unwieldy and the child develops a heavy, clumping gait. Boots afford more protection to the feet in bad weather, but from other points of view shoes are preferable ; partly because they admit more air to the feet, and also because they do not support the ankles which are thus encouraged to become strong enough to support themselves.

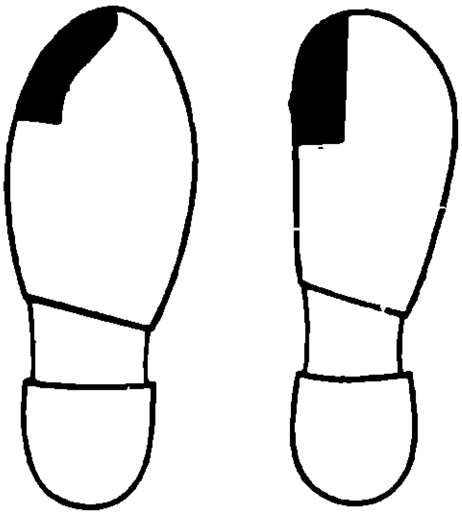


FIG. 76.—Wrong and right shoe shapes.

Too tight. — Boots and shoes should not be so tight as to compress the feet. Tightness may arise if the footwear is too narrow, too short, or of too small a size generally. When the weight of the body falls upon the foot, a general spreading out is produced, both from side to side and from heel to toes. A child's shoes should be sufficiently roomy to permit this spreading.

Wrong shape.—Fig. 76 illustrates correct and incorrect shoes viewed from the sole. The shaded part is the area occupied by the big toe in each case. A shoe which is badly shaped may cause the big toe to be bent round across the other toes, a deformity which easily becomes permanent and is a fruitful cause of bunions. A correctly shaped shoe has a straight inside edge and allows the big toe to extend forward in its natural position.

CHAPTER 19

POSTURE, EXERCISE, FATIGUE, REST AND SLEEP

THE topics enumerated at the head of this chapter are more closely related to one another than would appear to be the case at first sight. The maintenance of posture is a form of muscular exercise and both may lead to fatigue, for the dissipation of which rest and sleep are necessary.

Posture.—A child's body, especially the skeleton, is more plastic than that of an adult, and consequently is more easily deformed by habitual faulty posture. As the school child spends so much of his time sitting in a desk, the proper choice of these appliances and the regulation of the sitting posture are very important.

Sitting.—If the desks in a classroom are to be used by children of very varying size they must be adjustable, or else an assortment of different sized desks must be provided. Adjustability can be overdone: all that is really necessary is a means of altering the height of the seat and the relation between seat and writing surface. To be satisfactory a seat should be broad enough from back to front to support the greater part of the child's thigh from the buttock to the knee and should be horizontal. A narrow ledge, or a seat which droops downward and forward, encourages fatigue owing to the effort which is necessary in order to maintain a position upon it. There should be a back to the seat of sufficient height to afford real support to the back of the occupant. A backless stool or form is undesirable. The feet should rest easily upon the floor or upon a suitable footrest. If the legs are allowed to dangle unsupported the circulation of blood in the veins

is discouraged. The seat and the desk proper may be placed in three relative positions which are shown in Fig. 77. The zero position is that in which the front edge of the seat is vertically under the back edge of the desk. In the minus

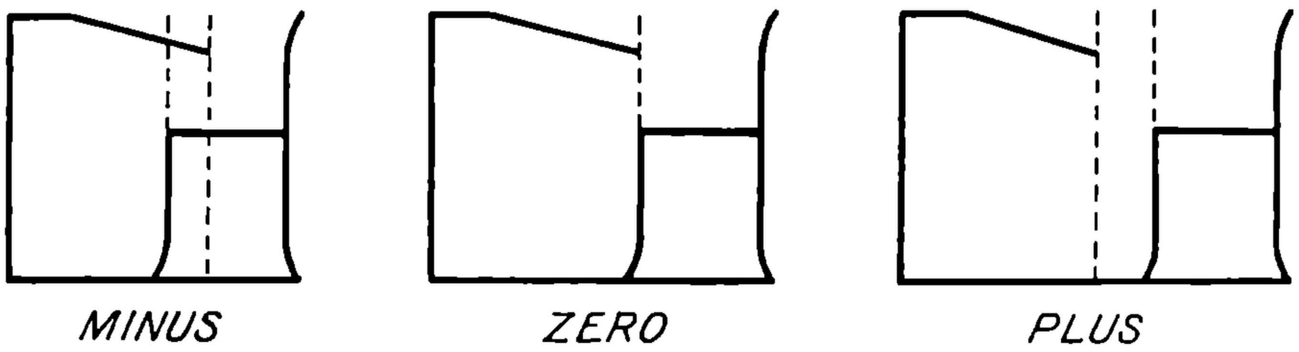


FIG. 77.—Desk positions.

position the two overlap and in the plus position there is a space between the seat and the desk. For writing, drawing and similar occupations, the minus position is best. For some other activities and for ease of access adjustment

FIG. 78.—The minus position in use.

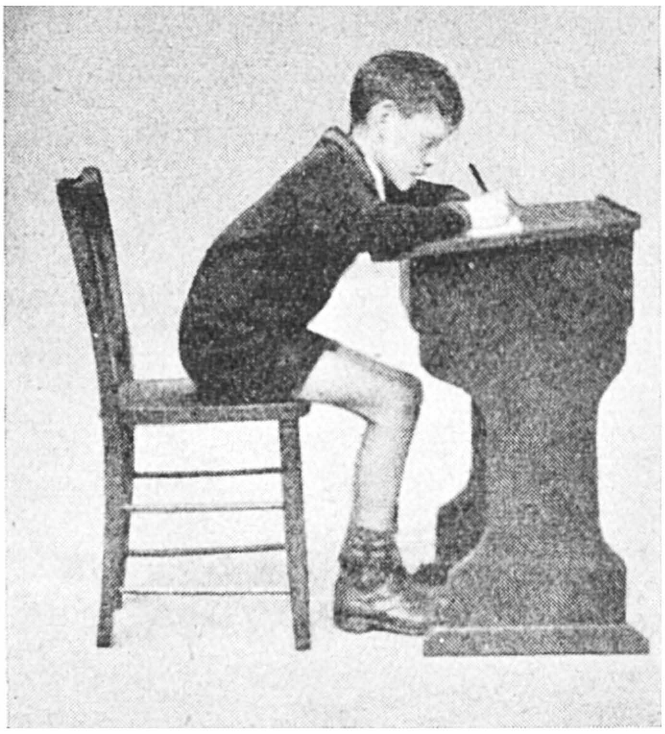


FIG. 79.—The plus position wrongly used.

to the plus position should be possible. No difficulty arises if separate chairs are used, but the movement of chairs is liable to cause an excessive amount of noise in school. Fig. 78 shows the use of the minus position for writing. By sitting close enough to the desk the child is able to

maintain a reasonably upright position. If writing is attempted in the plus position, as shown in Fig. 79, an uncomfortable, cramped position has to be adopted with the eyes too close to the work (see Chapter 20).

Standing.—Fig. 80 shows both good and bad standing postures. The correct posture is where the weight is borne equally upon the two legs so that the pelvis is horizontal and the weight of the trunk is vertically over a point midway between the two feet. If one knee is bent, undue weight is thrown upon the straight limb. The bent leg also causes tilting of the pelvis and, since the spine is fixed into the pelvis at right angles, a spinal curve must be maintained to bring the head vertically above the midpoint between the feet. This spinal curvature also causes the shoulder girdle to be tilted out of the horizontal. The occasional adoption of such a posture is of no importance, but if a child frequently and habitually stands in this way some permanent curving of the spine may result. Faulty posture may also force the spine into abnormal curves from front to back. This occurs if the hips are thrust unduly back or forward or if the head is allowed to droop upon the chest.

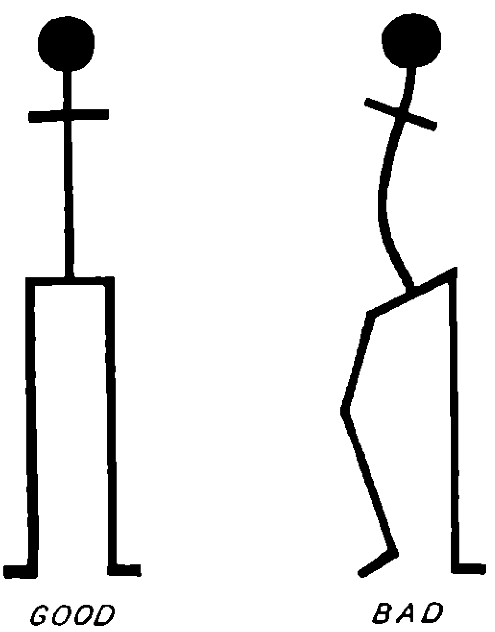


Fig. 80.—Good and bad standing postures.

Exercise. Muscular exercise has already been discussed in Chapter 4, where the local and general effects of exercise were described. The particular advantages of organized exercise and games were pointed out. In physical training the chief concern is with the voluntary muscles and the events connected with the contraction of a voluntary muscle may be briefly summarized. Contraction occurs when an impulse travels along a nerve to the muscle. Food material is then oxidized, movement occurs, and heat and waste materials are produced. The muscle becomes shorter and at the same time fatter.

Results of exercise.—In the Introduction to the Syllabus of Physical Training for Schools issued by the Board of Education, the benefits of muscular exercise are described under two headings: educational and physical. Educational benefits are the training in co-operation, discipline and co-ordination which class exercises and team games are supposed to give. Physical benefits have been described as nutritive (improved circulation, etc.), corrective (counteraction of habitual bad posture), and developmental (muscles become bigger and stronger with use). The description of the effects of exercise given in Chapter 4 agrees with this although expressed somewhat differently.

Conduct of exercise.—It is generally considered that formal physical exercises are not suitable for children under the age of eight years, and children with certain diseases (heart disease, deformities, etc.) will never be able to participate in ordinary physical training. Physical training lessons should be short and frequently repeated rather than long and at infrequent intervals. The exercises should be graded according to the age of the children, and should be varied to avoid monotony which produces boredom and impairs the value of the work. If possible, physical training should be performed in the open air or at least where fresh air has easy access. Suitable clothing and footwear should be worn and, if a special outfit cannot be arranged, children should at least remove some of their ordinary clothing.

Fatigue.—Fatigue is a term which is loosely used and is employed in varying senses. There are both physiological and psychological concepts of fatigue. As it occurs in school life fatigue may be defined as a diminished capacity for working, and the state may arise as a result of physical or mental effort.

Causes of fatigue.—It is thought that physical fatigue, at least, is caused by the accumulation of the waste products of activity which require time and rest for their removal.

Prolonged exercise allows no opportunity for the dissipation of these substances. Although muscles can be experimentally fatigued until they can no longer contract, in actual life the nervous system is affected long before the muscles. If a man does hard manual labour until he can work no more, his muscles will still contract vigorously if directly stimulated by an electric current. This indicates that the fault lies in the nerves which are no longer conducting impulses to the muscles.

Symptoms of fatigue.—As has been mentioned, the chief symptom of fatigue is diminished capacity for doing work, especially that particular work which has caused the fatigue. Thus a person who has become fatigued at one occupation may nevertheless be able to take up another of a different type. If an occupation is continued until extreme fatigue has occurred then the individual may become unfit for work of any description. In children, incipient fatigue is indicated by wandering of the attention, as this is Nature's way of trying to prevent the child's overdriving his body. An extreme form of fatigue which occurs in people who have been subject to continuous overwork and much worry is that popularly known as a "nervous breakdown."

Treatment and prevention of fatigue.—Extreme fatigue can only be removed by sleep but moderate degrees may be treated by rest without sleep. It may be largely prevented in school life by making the lessons reasonably short so that there is frequent change of occupation. Lessons should not, however, be too short otherwise time is wasted in "warming up" at the beginning and efficient working is not achieved before the end of the period arrives. Throughout the time table there should be an alternation of brain work with hand work or physical training, reading and writing with oral lessons and so on. When, for any reason, fatigue (as indicated by inattention) occurs during a lesson it can often be prevented from developing by relief drills: having the children stand in their places and perform a few simple physical exercises.

Rest and Sleep.—The nature of sleep is not fully understood and a number of interesting theories have been put forward to account for this phenomenon. It appears to be a time during which the body can attend to matters of repair and the disposal of waste products unhampered by activity. An alternation of periods of activity and periods of rest is characteristic of almost all living things. This alternation is diurnal in man and the higher animals and seasonal in the case of plants. Those animals which hibernate or æstivate show seasonal as well as diurnal alternation and even man shows some indication of the seasonal change. It is a common experience that we can manage with less sleep in summer than in winter.

Physiology of sleep.—Sleep is characterized, physiologically, by cessation of all non-essential activities and by slowing down of the essential ones (like the beating of the heart) which must, of course, continue. The heart, for example, beats more slowly and with less force during sleep as there is not the same demand upon the circulatory system in the absence of activity. Breathing is also slower as there is less urgent need for oxygen. To compensate for the slowness, however, each respiration tends to be deeper than when awake. Some observers have found that the blood supply to the brain is diminished during sleep, presumably because there is less nervous and mental activity. The general depression of physiological function results in a lowering of body temperature, an effect which is increased by the sluggishness of the circulation.

Quality of sleep.—The quality or depth of sleep varies in different people and at different times in the same person. Fig. 81 is a graph which indicates these variations. The region above the base line represents wakefulness and that below the base line represents sleep. The continuous black curve is the normal pattern of sleep such as would be seen in a savage rather than in a civilized person. In sleep of the normal pattern, the individual falls asleep fairly quickly and reaches a maximum profundity in about

an hour. Sleep remains deep for two or three hours and then begins to get lighter. Eventually, some slight sound, or the sleeper's own movements, terminates the sleep. The depth of sleep may be estimated by striking a gong at intervals. When sleep is deep a quiet note from the gong will not be sufficient to rouse the person who is the subject of the experiment. As sleep becomes lighter there comes a time when the same sound is sufficient to penetrate into consciousness and arouse the sleeper. Civilized people often deviate from this normal pattern of sleep because they have many interests which lead them to stay up late at night, assisted by artificial light which the savage lacks.

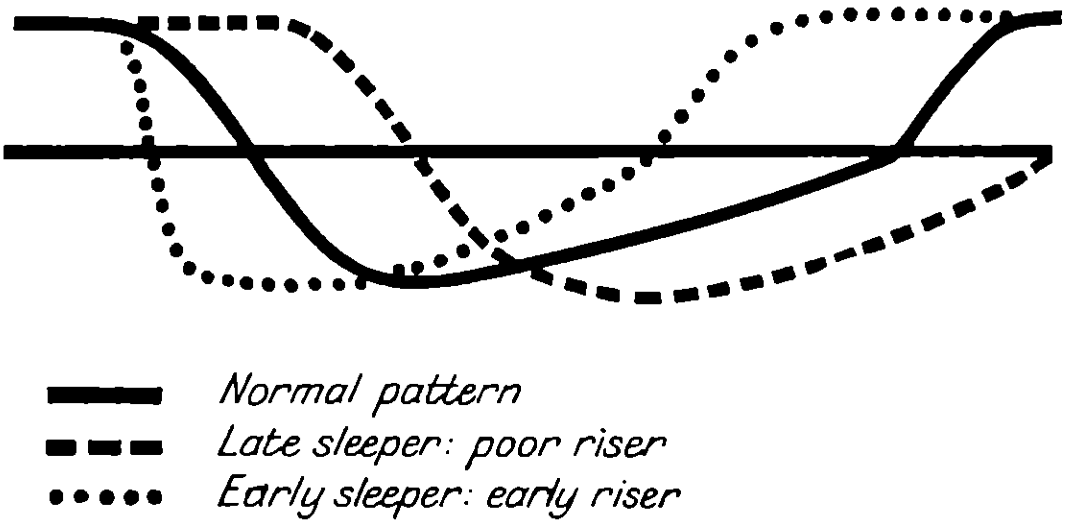


FIG. 81.—The quality of sleep.

Consequently, they fall into deep sleep at a time when they ought really to be rousing. Therefore they have to rely upon the artificial stimulation of an alarm clock to rouse them, instead of waking at the mere sound of birds and animals beginning a new day soon after dawn. Some people never become fresh and thoroughly fit for work until comparatively late in the morning. Others, who wake up alertly enough, tire at the other end of the day and need to go to bed early. There are thus many individual variations in the quality of sleep.

Quantity of sleep.—At different ages people require different amounts of sleep. A very young baby spends nearly all its time (apart from feeding) in sleeping, and infants generally need about twenty hours of sleep out of

the twenty-four. A child of four needs about twelve hours' sleep. At eight, nine or ten hours, at fourteen, eight or nine hours, and when adult life is reached, eight hours. Here again there are many individual variations. Some adults require as much as nine hours' sleep regularly, while others can manage on as little as five. Seven to eight hours, however, represents the average, the necessary requirement being somewhat less in summer than in winter.

Rest and sleep in schools.—As children require so much sleep, it may not be convenient for them to have it in one continuous period at home. In any case, children often do not have sufficient sleep owing to parental ignorance or

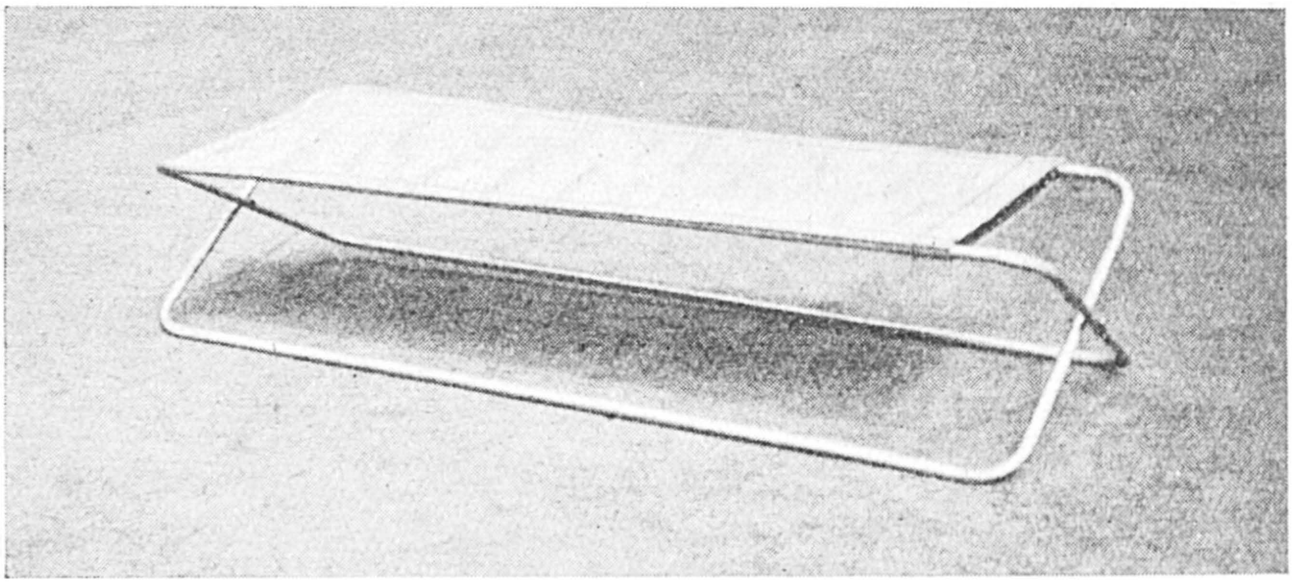


FIG. 82.—Sleeping couch.

neglect. For these reasons, it is usual to provide a rest period in school for young children. This is best given in the afternoon, as the child can get through the morning on his night's sleep, but after mid-day begins to feel fatigued, or would do so if a rest were not allowed. Some provision should be made for sleeping other than upon the floor, as this tends to be both draughty and dirty, even if a mat is provided. The best type of couch is a simple stretcher device such as that shown in Fig. 82. The head end should be slightly higher than the foot and, if the rest is taken in the open air (as it should be whenever the weather permits), the child should be covered by a blanket. String hammocks are undesirable, as they tend to sag and so induce bad

posture. Composite resting beds or hammocks are clumsy and in other ways disadvantageous as compared with individual ones.

Notes on sleep.—Some miscellaneous remarks upon sleep may be made at this point. It is desirable to adopt a horizontal position for sleeping for two reasons. Such a position permits muscular relaxation which is impossible in any other position (such as sitting) where muscular contraction is necessary to maintain the posture. The horizontal position also involves less work for the heart as the influence of gravity is largely removed from the blood vessels. Nevertheless, it is desirable that the head should be slightly raised as this assists blood to drain away from the brain as required during sleep.

Soft bedding is good in that it promotes muscular relaxation and so rest. Warm covering is useful in the same way and is also necessary to compensate for the fall in body temperature which occurs during sleep. Absurdly spartan habits in respect of bedding are not necessarily hygienically sound. Good hygiene should never mean discomfort.

Falling asleep is in the nature of a conditioned reflex and so a regular bedtime is valuable, especially in training children. As the individual remains in the one atmosphere for so many hours together proper ventilation is very necessary in the bedroom. It is not usually desirable to take a large meal just before going to bed as the alimentary canal ought to take its rest along with the other parts of the body. Sometimes, however, a very light meal may assist sleep by drawing blood from the brain to supply the stomach. Outside stimulation must be avoided if sleep is to be secured and it is for this reason that we seek a quiet and dark room for our rest. A very common source of irritating stimulation which prevents sleep is coldness of the feet, intensified as the circulation becomes sluggish during the night. A hot water bottle is very useful in preventing this and also serves to dilate the blood vessels of the feet, which again draws blood away from the brain.

CHAPTER 20

THE EYE AND VISION

So much of education necessitates the use of the eye that the care of this organ is of great importance. In order to understand the rationale of visual hygiene, it is necessary to have some knowledge of the normal structure and function of the eye. These aspects of the question will be described first before considering the matter from the view-point of education.

Structure of the Eye

When the skin was described in Chapter 8, reference was made to nerve endings by which we experience the sensations of touch, pain, etc. In Chapter 9 the special nerve endings for the sensations of smell and taste were also described. The eye is another special nerve ending, or rather a collection of nerve endings, designed to respond to the action of light. The senses previously mentioned require actual contact between the body and some other object. Even the sense of smell necessitates the entrance of fine, odoriferous particles into the nose. The eye (and the ear) requires no such contact for the performance of its work : it enables an individual to acquire information about his environment at a considerable distance.

The Eye as a Camera.—From some points of view, it is useful and instructive to compare the eye to a camera. Such a comparison must not be pushed too far, or it leads to misconceptions. Fig. 83 represents an ordinary box camera, such as a Brownie, seen in section, and a corresponding section of the eyeball for comparison. The camera is a rigid box, generally of rectangular shape. The eye is

also a fairly rigid, fibrous structure of roughly spherical shape. In front of the camera is the shutter, a device for excluding light or admitting it into the interior at will. The *eyelids* correspond to the shutter and serve a similar purpose. Behind the shutter of the camera there is usually a diaphragm or stop. This is a piece of metal perforated by holes of different sizes which may be used to adjust the amount of light entering when the shutter is open. To take

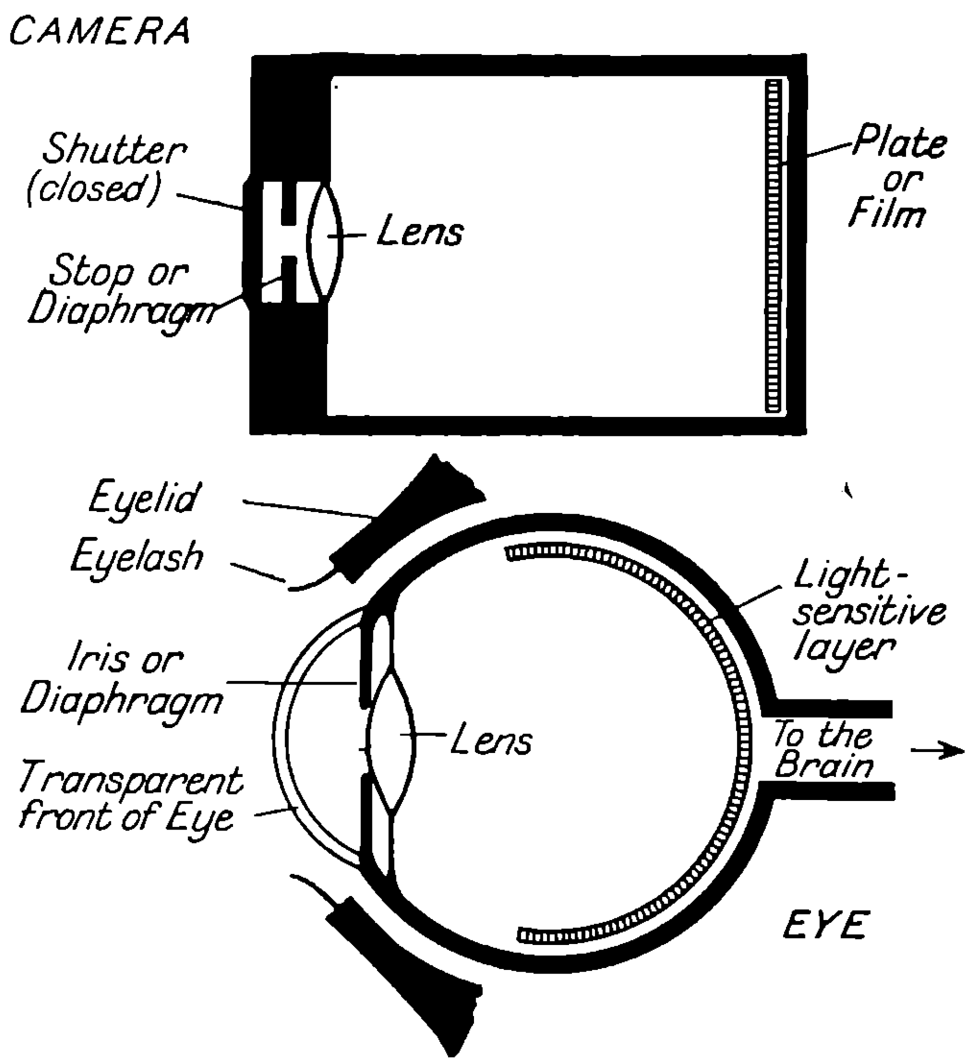


FIG. 83.—The eye as a camera.

a photograph in a bright light a small hole would be employed, a larger hole being used when the light was poor. The corresponding structure in the eye is known as the *iris*, the coloured portion of the eye with a hole, the *pupil*, in the centre. The iris moves in different kinds of light and adjusts the size of the pupil, making it large or small as the circumstances require. Behind the diaphragm of the camera is the lens, a curved piece of glass which brings the entering light to a focus. The eye also contains a *lens*, made of clear, transparent cells, which acts like the lens of

the camera. At the back of the camera is the sensitive plate or film and, when light acts upon this, chemical changes take place on its surface. Further chemical changes, in the process known as developing, produce a permanent image in the form of a negative. The back of the eye is also sensitive to light, but here the comparison with a camera breaks down, as no permanent image is formed within the eye. The cells which form the light-sensitive layer of the interior of the eyeball are nerve cells of a sort. Each is connected to the brain by a long nerve fibre, a bundle of such fibres leaving each eye as the *optic nerve* or nerve of sight. When light falls upon these cells chemical changes take place in their protoplasm, giving rise to nerve impulses which travel to the brain, which thus receives information about what is going on in the outside world. The chemical reactions within these cells are not permanent like the chemical reactions upon the surface of a photographic film. The matter will be understood by comparing the light-sensitive cells to an audience of people in a darkened theatre looking at the stage. If each member of the audience was connected by telephone with some person in another building to whom he described what he saw upon the stage, the absent person might piece together the information and so gain an idea of what had taken place in the theatre. No "picture" would have been formed upon the audience. The cells of the eye are looking out on to the world in just this way and are continually transmitting information to the visual centres of the brain.

The Eyelids.—Each eyeball is contained in a socket in the skull, known as the *orbit*. It is thus well protected from injury except in front, where there must, of course, be an opening for the admission of light. This opening is guarded by the eyelids. The eyelids are able to move by virtue of fine muscles of which they are composed, the whole being covered by skin on the outer side. Fig. 84 represents two views of the eyelids, open and closed, as they would appear if the skin were removed and the muscles could be seen. The orbits are shown beneath the

muscles. Some of the muscles are arranged in an oval running round the edge of the lids. These muscles are bound down to the bone of the face at the inner and outer corners of each orbit. When they contract the result would be to form a smaller oval, but since each end is fixed the open space between the eyelids becomes narrower

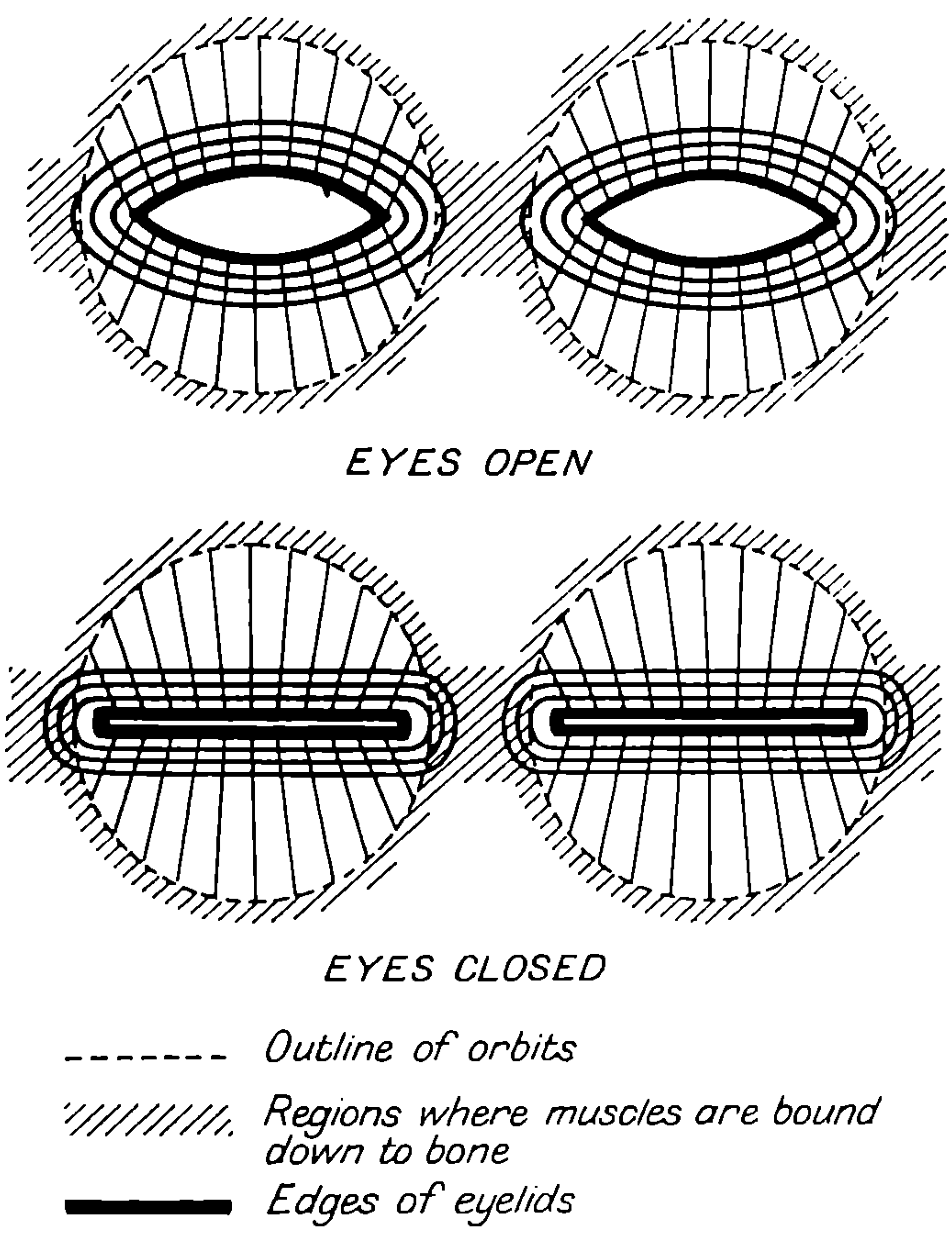


FIG. 84.—The muscles of the eyelids.

and narrower until the eyes are closed. Other muscles run more or less vertically from the lid margin to the edge of the orbit above and below where they are fixed down to the bone. When these muscles contract they pull upon the edges of the lids and so cause the eyes to open. The *eyelashes* are hairs which afford some protection to the eye even when the lids are open.

The Eyeball in the Orbit.—Fig. 85 shows a section of the orbit as viewed from the side. Above is the general cavity of the cranium containing the brain. Below is the cavity of the nose. These relationships will be understood if the skull is considered as it was described in Chapter 3. At the back of the orbit is a small opening through which the optic nerve runs on its way from the eyeball to the brain. The eyeball does not entirely fill the orbit, being surrounded by a quantity of fat which thus cushions it

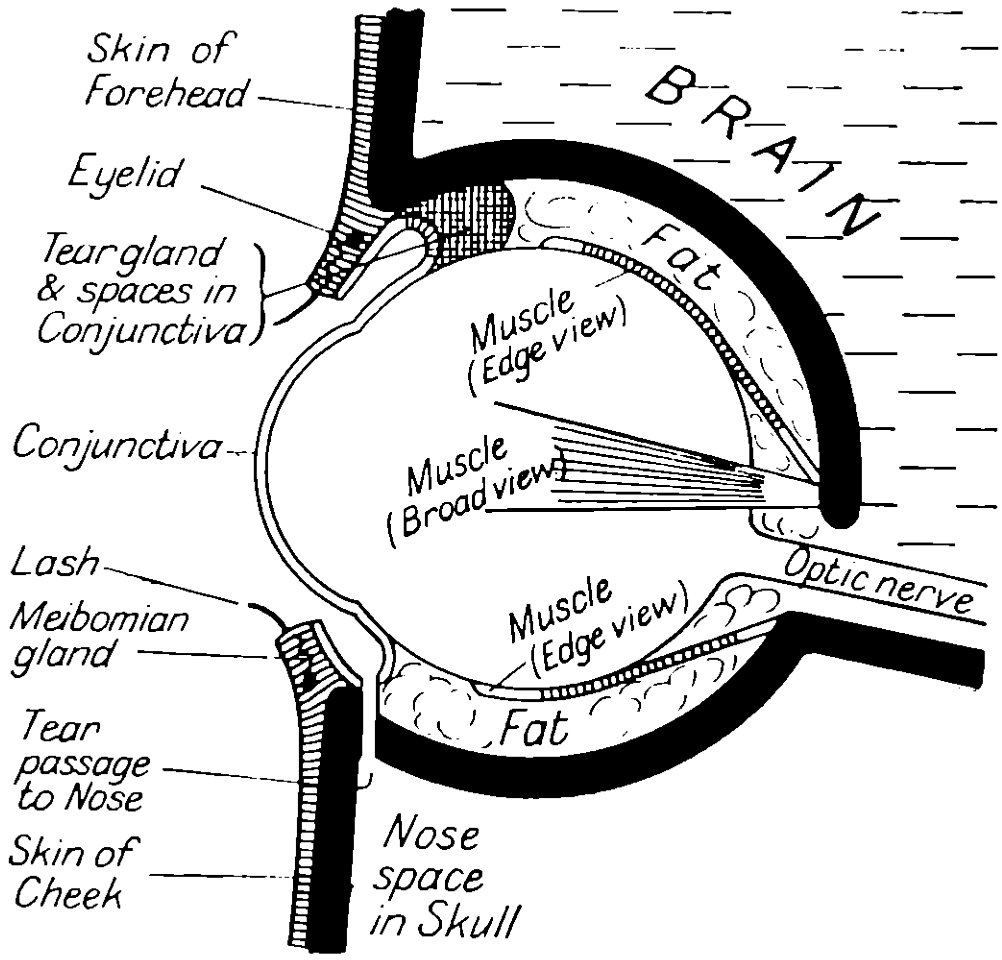


FIG. 85.—The orbit in section (diagrammatic).

against shocks, and leaves it free to make the ordinary movements of looking from side to side or up and down.

The Eye Muscles.—The movements of the eye are produced by the action of muscles. They look something like small, flat straps, and run from the eyeball to the deep part of the orbit where they are attached to the bone all round the aperture through which the optic nerve passes to the brain. Some of these muscles are shown in Fig. 85. If the upper one contracts, it rotates the eyeball upwards. The others produce other movements, and combinations of

several muscles acting at once can turn the eye in any direction.

Conjunctiva.—In order to protect the contents of the orbit while the eyelids are open a thin, transparent membrane covers the front of the eye. It is called the conjunctiva and, although thin enough to be transparent so that it does not interfere with the passage of light, it is thick enough to prevent the entry of germs and other impurities into the orbit. The conjunctiva is seen in section in Fig. 85. It begins behind the upper eyelid, passes round on to the eyeball and eventually turns up behind the lower eyelid. The interior of the orbit is thus entirely cut off from the outside, and two conjunctival pockets are formed behind the two lids. A blow upon the eye sometimes causes the conjunctiva to be suffused with blood (a bloodshot eye) thus demonstrating its presence, although in health it is not noticeable.

The Tear Gland.—Above the eyeball, and embedded in the fat of the orbit, is a small, fleshy mass of cells forming the tear gland. As its name implies, the function of this gland is to produce the watery liquid known as tears. The tears pass from the gland through a number of holes in the conjunctiva and trickle across the front of the eyeball, thus keeping it washed and free from dust. The fluid collects in the lower pocket of the conjunctiva and eventually drains away through a little passage in the bone into the nose. When tears are produced in excess, as in weeping, they overflow beyond the eyelid on to the cheek. At the same time the nose feels moister than usual owing to increased drainage through the passage already described.

Meibomian Glands.—It has been shown that the roots of hairs are connected with sebaceous glands which produce a lubricating grease. Near the roots of the eyelashes in the eyelids are somewhat similar glands, but much larger, and opening independently upon the lid edges. These are called Meibomian glands, after the man who discovered them. They produce a greasy secretion which serves three

functions. It lubricates the edges of the eyelids and prevents undue friction as they rub against each other. It also forms a greasy barrier across which the watery tears do not readily pass unless they are produced in excessive quantity.

The Eyeball.—The eyeball itself must be considered next. As the name implies it is more or less spherical in shape and is hollow like a football. It consists of several coverings or coats which are arranged concentrically (Fig. 86), just as a football has an outer jacket of leather

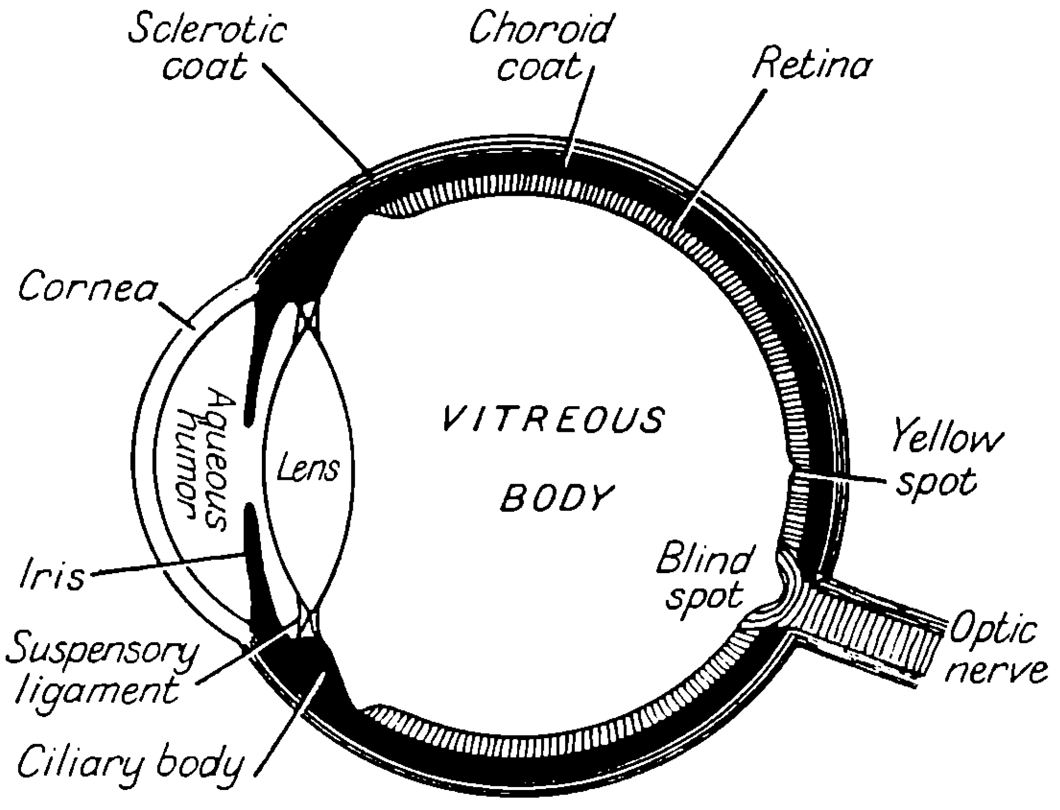


FIG. 86.—The eyeball in section viewed from above.

surrounding an inner bladder of rubber. The outermost covering is the *sclerotic coat*. This is tough and fibrous, and serves to maintain the spherical shape of the eyeball and prevents distortion. The sclerotic coat is white in colour and is visible in the front part of the living eye as "the white of the eye." The front part of the eye has to be transparent in order to admit light into the interior. In this region, therefore, the sclerotic coat gives place to the transparent *cornea*, the clear window which covers over the coloured portion of the eye. These two structures together form the outer coat of the eyeball. Within the sclerotic coat is the *choroid coat*. The cells of this layer

contain black pigment which darkens the inside of the eyeball and so prevents dazzling reflections of light which might interfere with vision. It is for this same reason that the interior of a camera is painted black. Towards the front of the eyeball the choroid coat becomes fatter, forming a structure known as the *ciliary body* which runs round the eye as a thickened ridge in this region. Further forward still the choroid coat is continued as the *iris*, the part of the eye which is coloured blue, brown or grey in different individuals. Looking at a living eye from the front, the iris is seen as a circular curtain with a hole in the middle. This hole is the *pupil* and always appears dark, as through it we see the dark interior of the eye. The back portion of the eyeball has a third coat, the *retina*. This is made of cells which are sensitive to light and so is the real seeing part of the eye.

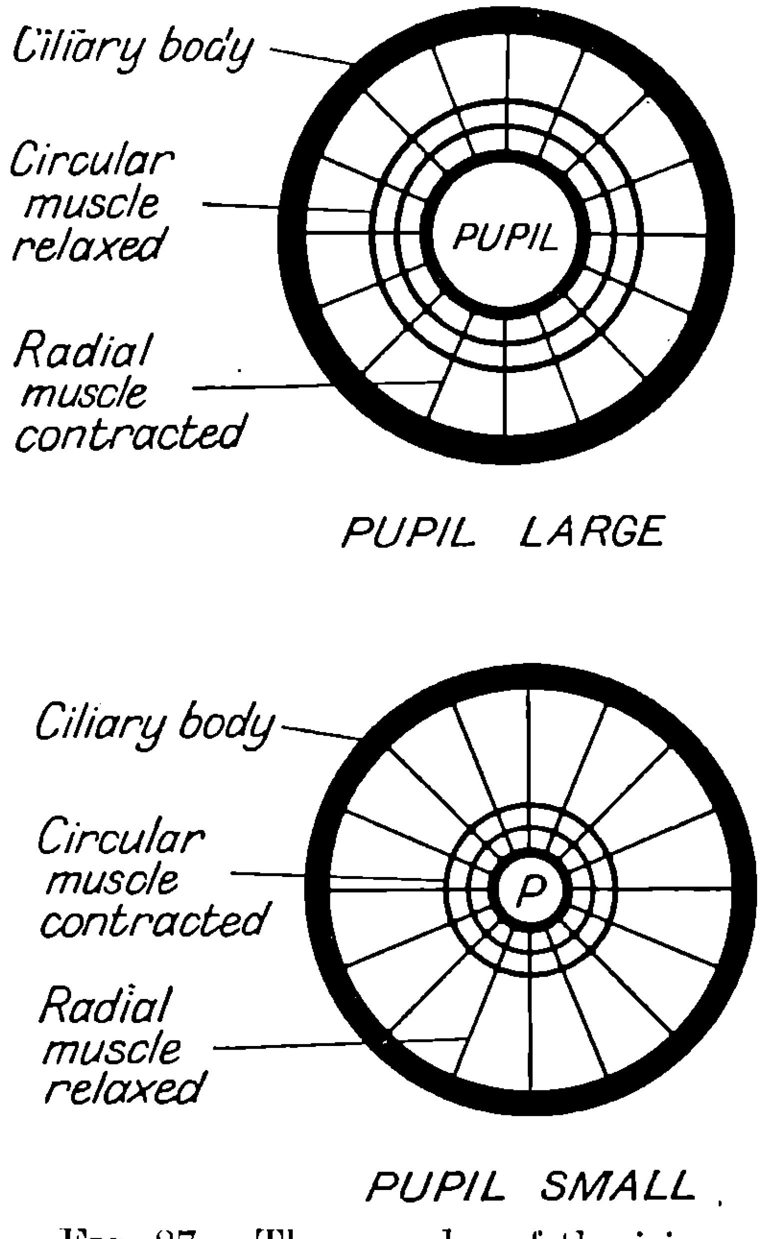


FIG. 87.—The muscles of the iris.

The Iris.—The iris, which has been mentioned above, contains muscles which are arranged in two directions somewhat like the muscles of the eyelid. One group of muscles runs in circular fashion round the pupil. Another group runs radially from the edge of the pupil towards the ciliary body with which the edge of the iris blends. The function of these muscles is to regulate the size of the pupil. When the circular muscles contract the result is like drawing

up a purse string and the pupil is diminished in size. When the radial muscles contract the pupil is increased in size (Fig. 87). The pupil is small when you are in a bright light as the entrance of too much light into the eye would be harmful. On going into darker surroundings the pupil becomes larger. The alteration can be seen by standing before a mirror with the eyes closed and covered by the hands. If the hands are suddenly removed, the eyes opened and their reflections examined in the mirror, the pupils will be seen diminishing in size in response to the sudden access of light. Similar changes take place in the eye of a cat, only its pupil is not always a circular opening. By day it is a narrow slit excluding the excess of light: by night it is a very wide opening admitting every possible ray of light. The colour of the iris is due to pigment, deposited there to prevent light passing through the curtain itself.

The Retina.—The retina is composed of nerve cells which are sensitive to the action of light. When light shines upon them chemical changes take place in the cells and nerve impulses travel to the brain. The cells of the retina do not communicate directly with the brain but hand on their impulses to other nerve cells which form a chain of neurones between the eye and the visual centres of the brain. In Chapter 9 it was explained how nerve impulses in other parts of the body are passed from one nerve cell to another in this way. The part of the retina directly behind the pupil is somewhat yellow in colour and is called the *yellow spot*. This contains the most efficient arrangement of visual cells and an object in the outside world is most distinctly seen when its image falls upon this part of the retina. If the eyes are directed towards some object in a room so that its image falls upon the yellow spots, that object is sharply focussed and clearly perceived. Surrounding objects are focussed upon other parts of the retina and, although seen, are not so distinct as the thing which is the centre of attention: they are seen out of the "eye corner."

Another special part of the retina is the *blind spot*, illustrated in Fig. 88. This figure represents some light-

sensitive cells of the retina and nerve fibres running from them to the brain. The diagram has been reduced to very simple terms and in reality the nerve fibres would belong to cells near to those which are light-sensitive, having received impulses from them. Notice the curious arrangement of these nerve fibres. They run along the retina along the inside of the eyeball so that light has to shine through them to get at the visual cells. At the blind spot all these fibres turn at right angles to enter the optic nerve on their way to the brain. As this part of the retina is occupied by these right-angled bends there is no room for light-sensitive cells at this point and so this region of the retina is blind and plays no direct part in vision.

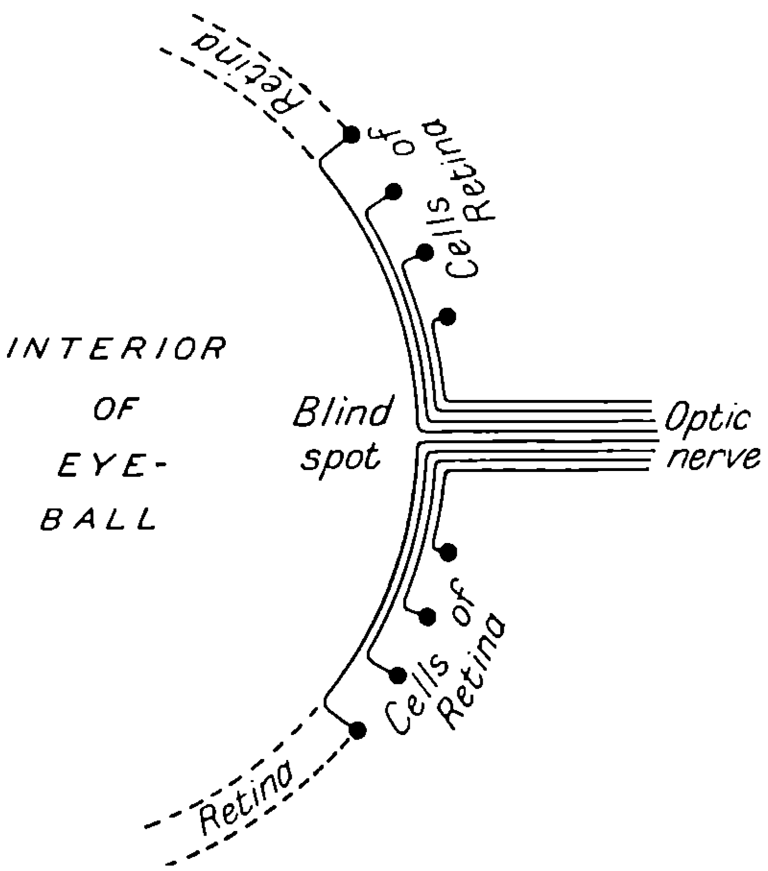


Fig. 88.—The blind spot.

The Lens.—It is not enough for light to pass through the pupil and strike the retina: it must be focussed to give a sharp image. Focussing is brought about by the lens, a structure made of perfectly transparent cells, placed immediately behind the pupil. The lens is kept in position by *suspensory ligaments* which run as fine strands from the edge of the lens to the ciliary body. From in front the arrangement may be compared to the wheel of a motor car. The lens represents the hub, the suspensory ligaments the spokes, while the thick ciliary body represents the tyre.

Vitreous Body.—The interior of the eyeball is not empty. It is filled by a transparent, jelly-like mass, the *vitreous body*. The presence of this substance increases the solidity and stability of the eye without interfering with

vision. Vitreous means "like glass" and refers to the transparency of the body, not to its consistency.

Aqueous Humor.—If the front part of the eyeball were filled with a similar jelly the movements of the iris would be impeded. To avoid this a more fluid substance occupies this region; it is called the aqueous humor which means simply "watery liquid."

Function of the Eye

Light and Lenses.—In order to understand how the eye works, it is necessary to know something about light

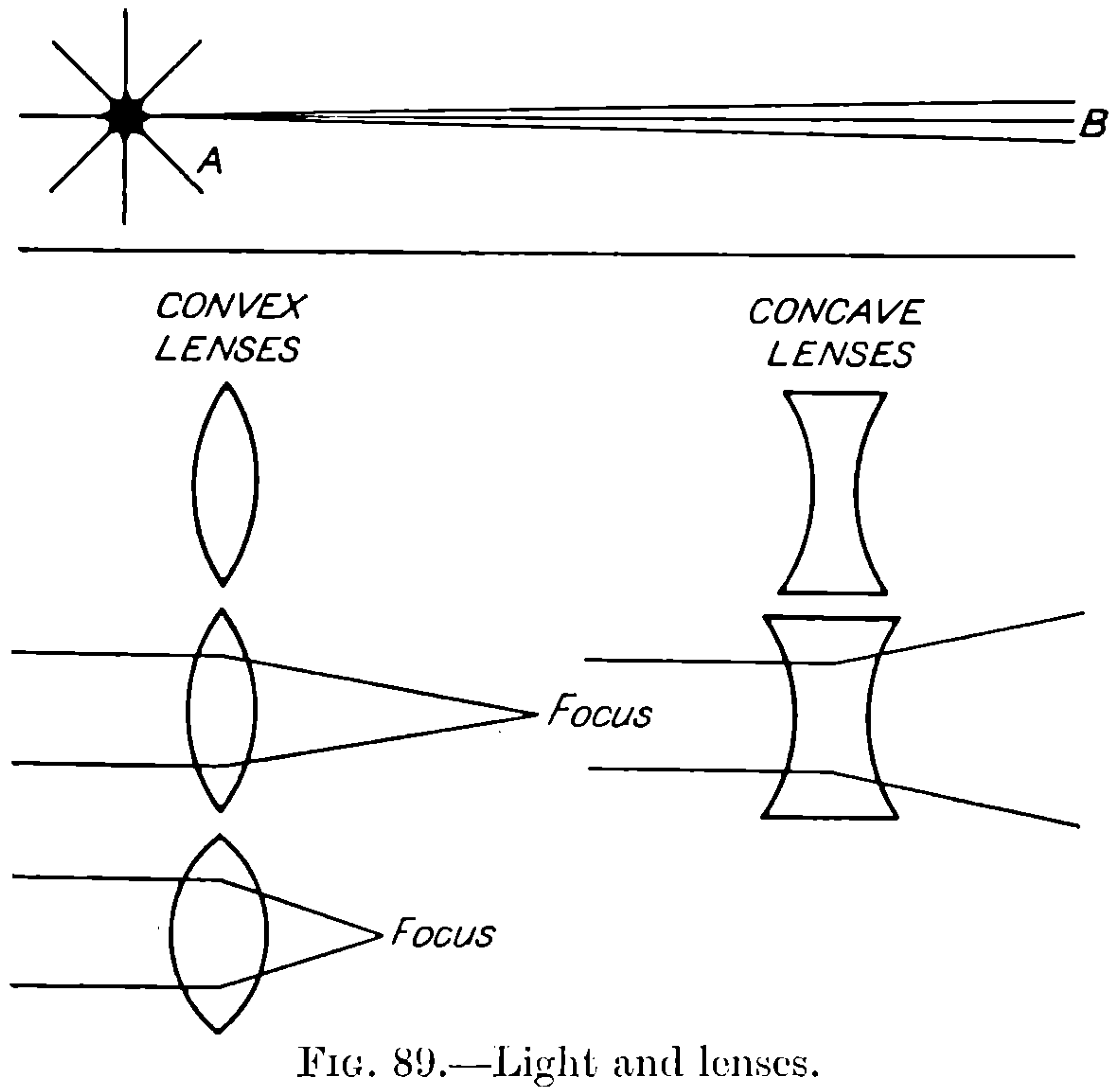
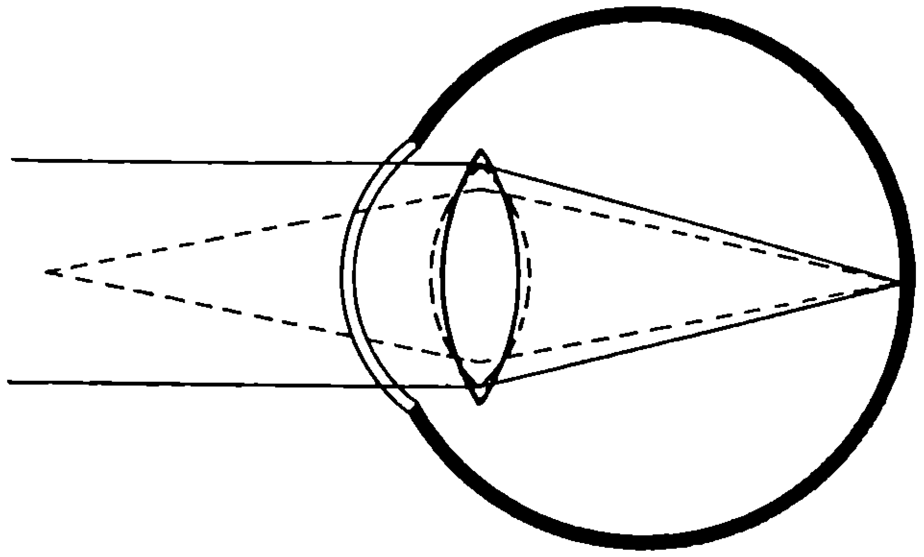


Fig. 89.—Light and lenses.

and the action of lenses. Fig. 89 shows an object giving out rays of light. Some objects (a candle, an electric light) are self-luminous, others (a book, a picture) merely reflect light received from other sources. In either case the light travels from the object in all directions in straight lines. If the eye is placed near to the object (at A in the figure) it is in a region where the rays of light are diverging

from the object like the spokes of a wheel. If the eye is far from the object (at B in the figure) the rays of light, although diverging slightly, may be regarded as parallel for all practical purposes. Thus, when reading a book, diverging rays of light are entering the eye from the page. When looking at a blackboard from a distance, parallel rays of light are entering the eye.

A lens may be very roughly defined as a curved piece of glass which has the power of bending rays of light. If the lens is thicker in the middle than at the edge it is termed



——— *Light from distant object and unaccommodated lens*

- - - - - *Light from near object and accommodated lens*

FIG. 90.—Accommodation for near vision.

convex (Fig. 89). An ordinary magnifying glass is a lens of this type. If the lens is thinner in the middle than at the edge it is termed *concave*. An artist's diminishing glass is a lens of this type. A convex lens bends rays of light (whether diverging or parallel) and brings them together at a point known as the *focus*. The thicker the lens the greater its bending power, and consequently focussing is effected in a shorter distance. A concave lens bends rays of light apart and so does not effect a focus.

Accommodation.—As the eye is used for looking at both near and distant objects, it has to be capable of dealing equally with diverging and parallel rays of light. When

the eye is at rest parallel rays of light from a distant object are focussed upon the retina. Rays of light from a near object are diverging and so require more bending in order to focus them upon the retina. It has just been stated that greater focussing power is obtained by using a thicker lens: consequently, the lens of the eye must become thicker when looking at a near object. The power of the lens to change its shape in this manner is called the *power of accommodation* (Fig. 90). It has been shown that the lens is attached by suspensory ligaments to the ciliary body, a structure which contains muscles running round in a circumferential direction. When these muscles contract the ciliary body becomes a smaller ring, tension upon the suspensory ligaments diminishes and the lens, freed from the pull of these ligaments, bulges (Fig. 91). Accommodation for near vision therefore necessitates muscular exercise within the eye and prolonged accommodation may lead to eyestrain.

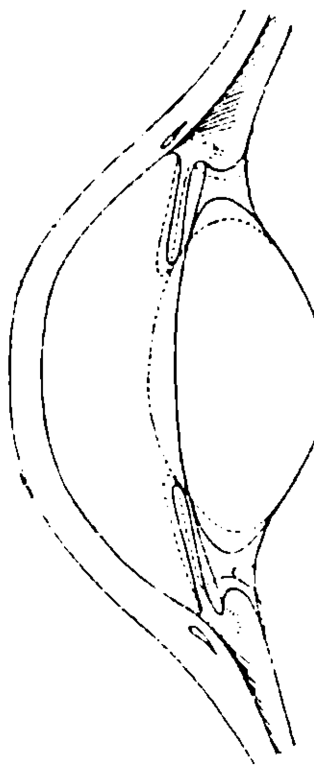


FIG. 91.—The lens in accommodation. (The dotted outlines show the arrangement for near vision.)

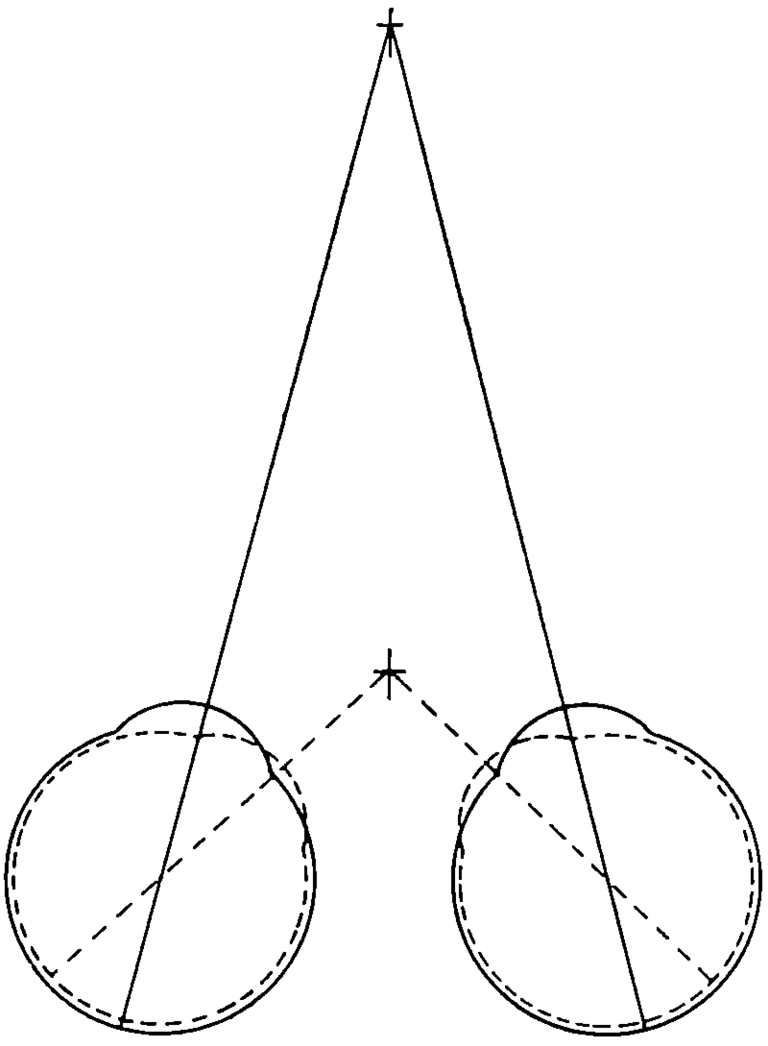


FIG. 92.—Convergence of the eyes.

Convergence.—When an object is close to the eyes they have not only to be accommodated, but must be turned inwards towards the nose in the process known as *convergence* (Fig. 92). This also involves muscular effort on the part of the muscles within the orbit which control the movements of the eye.

Hygiene of the Eye

In order to keep the eye healthy and to maintain normal vision, attention must be paid to certain points in school life. These will be briefly discussed.

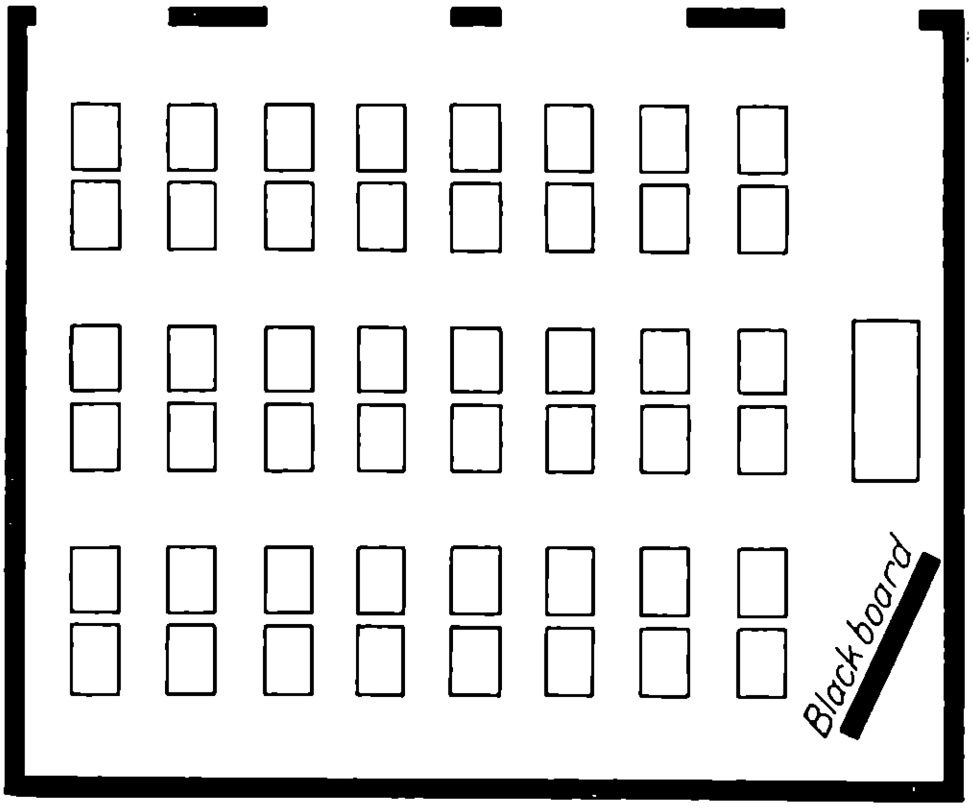


Fig. 93.—Arrangement of windows in a classroom.

Lighting. ***Daylight.***—Plenty of daylight should be admitted to the classroom, and to ensure this there must be sufficient window space. The windows should extend right to the ceiling, as more light enters the top part of a window than the bottom, since the top is more likely to be clear of neighbouring trees and high buildings. The windows should also come down reasonably near to the floor, certainly within four feet. As a child sits writing in his desk, his body obstructs light coming from behind and his outstretched right arm interferes with light coming from the right. Light should come from the left front to avoid these impediments.

Therefore, the windows should be along the left-hand side of the class-room and one window should be somewhat in front of the first line of desks (Fig. 93). Light should not shine directly in front of the class from behind the teacher, otherwise the children's eyes are likely to be strained in trying to see the blackboard and the teacher against the bright background. The dimensions of the classroom should be so adjusted that light from the windows reaches to the farther side. If additional windows are placed on the right-hand side, they should be smaller than the others, so that light from the left predominates. To increase the effect of daylight the walls and ceiling should be painted a light colour. White is not generally suitable for the walls, beige, yellow or light green being preferable : the ceiling, however, should be white. The lower part of the wall tends to get dirty quickly and may permissibly be painted a dark colour, or, better, tiled and so rendered washable.

Artificial light.—The best artificial light is provided by electricity. Open flames (gas, oil lamps) use up oxygen, heat the air and give out waste products of combustion. Lights of this type are also liable to flicker. Electric light has none of these disadvantages and nowadays is reasonably cheap. The best kind of electric lighting is indirect, diffused lighting, where the globes are so screened that all the light is cast on to the ceiling and evenly diffused down over the room. This avoids irregularity of illumination and the presence of dark patches in some parts of the room which nearly always occur with ordinary direct lighting. Indirect illumination is expensive and cannot be installed in all schools, as very powerful bulbs must be used, suitable fittings provided and the ceiling kept thoroughly white.

Regulation of Fine Work.—Reading, writing, sewing and many kinds of handwork are tasks in which the work is performed close to the eyes. This necessitates accommodation and it has been explained that accommodation means muscular exertion. To prevent undue strain upon the delicate eye muscles, fine work should only be carried

on for short periods. Lessons requiring accommodation should alternate with lessons making use of distant vision, with physical training or with oral work. As far as possible fine work should be performed in daylight, and this applies particularly to sewing. In winter, when artificial light has to be used during the afternoon, it is desirable to arrange the time table in such a way that close work is performed during the morning and early afternoon while daylight is still available.

Reading. ***Position.***—In reading, the book should not be held too close to the eyes otherwise excessive convergence and accommodation are called for. A distance of about twelve inches between the page and the eye is usually satisfactory, and if a child holds his book closer than this there is probably something the matter with his vision which requires investigation. The line of print should be parallel with the line joining the centres of the two eyes, as shown in the upper diagram of Fig. 94. This figure represents a page viewed through a child's eyes and the lower two diagrams indicate bad positions where the book is on the skew. In either of these latter positions the centres of the two eyes are over different lines of print. In order to read, the eyes must be jerked about in an irregular manner which is unnecessarily fatiguing. In the correct position (upper diagram) reading is accomplished by gently moving the eyes from side to side in an even manner along the lines of print.

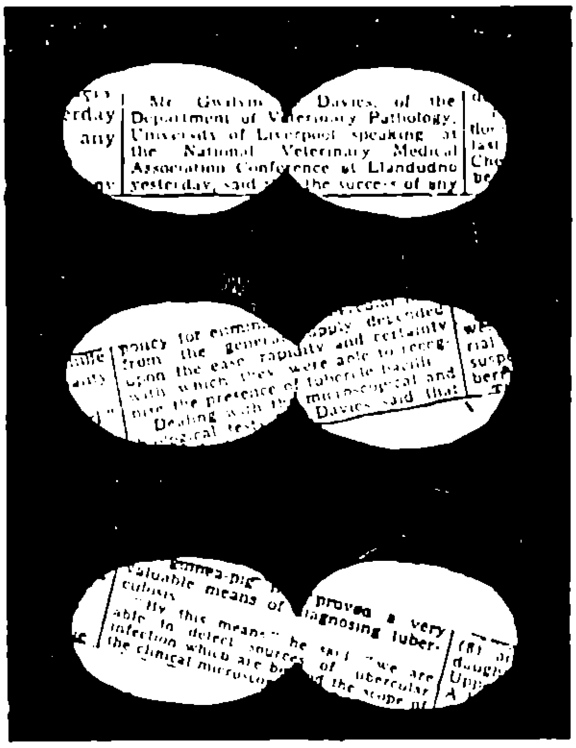


FIG. 94.—Good and bad reading positions.

Print.—In order to secure sharp contrast for the easier focussing of the eye, the print should be as black as possible upon paper which is as white as possible. The letters, too,

should have a clear outline. From this point of view, an ordinary newspaper is greatly at fault, as the print tends to be grey, the paper far from clear white, and the outline of the letters blurred. In a school book, the paper should be thick enough to prevent the print's showing through on the reverse side. If this occurs it interferes with the clarity of the type. Some thin papers, although expensive, are poor in this respect. The type used should not be too small, that known to printers as " small pica " representing the smallest permissible for senior children (Fig. 95). Young children need much larger type.

The size of this type is called "pica" or 12 point and it is 1 point leaded. It is suitable for children between 7 and 10 years.

The size of this type is called "small pica" or 11 point and it is 1 point leaded. It is suitable for children between 10 and 14 years.

FIG 95.—Types suitable for children's books. Children younger than 7 years require even larger types, known as 14 and 16 point.

The arrangement of the page of print is also a matter of some importance. In such a book as this the space between the lines is only sufficient for the letters in one line to be clear of the letters in the line below. Printing of this kind is said to be " set solid " and is suitable for older children and adults. Young children, especially those learning to read, find difficulty in keeping their place unless there is more space between successive lines. Extra spacing is obtained by inserting a strip of lead between the lines of type when the page is printed and consequently this arrangement is called " leaded," and should be used for the very young. The length of the line of print should not be too great as this also adds to the difficulty of keeping the place. A line of three and a half inches is the most satisfactory. Such a length permits about ten words of small pica type, but fewer if larger type is used. For children

up to seven years of age the three and a half inch line should not contain more than four or five words.

The Cinema.—Most children nowadays visit the cinema regularly and this is sometimes supposed to be harmful to the eyes. The cinema need not necessarily be harmful to vision provided attention is paid to certain points. Obviously the child should not go there with excessive frequency, and preferably should not be there late at night when tired and when the atmosphere is heavy with smoke. Children tend to occupy the front seats since these are usually the cheapest. This is not good for the eyes as the picture tends to flicker and is not sharply in focus. The screen is generally somewhat high up in relation to the front seats so that the head must be thrown well back and maintained in that position, which in itself represents a considerable muscular exertion when carried on for an hour or two at a time. Seats towards the back of the cinema are free from these objections and it has been suggested that children under fourteen years of age should not sit nearer to the screen than fifteen feet.

Sight Testing.—By means of certain tests it is possible to tell whether a child's sight is remaining normal or in what way it is departing from normality. Some tests of vision are highly scientific and give very accurate results. Simpler tests, sufficiently accurate for ordinary purposes, are carried out by the school nurse and the underlying principles should be understood by the teacher. The commonest method of sight-testing is by means of Snellen's test type (Fig. 96). This is a card on which are printed rows of letters which diminish in size from top to bottom of the card. Each row should be read by a normal eye at a certain distance. If a child can only read the large letters at a distance where he ought to read the smallest then obviously he is short-sighted. In using Snellen's type certain precautions are necessary. The card should not be kept permanently hanging up in the school or children may unconsciously memorize many of the letters. Moreover, a dusty card lacks contrast between the black print and the

background which ought to be pure white. The sight-testing room should be darkened but the card brightly illuminated, again in order to obtain sharp contrast. Each eye should be tested separately, the one not in use being covered by a piece of cardboard held in front of it. If a child is merely told to close one eye he can scarcely avoid partially closing the other. A piece of cardboard does away with this difficulty and, if held by the teacher, prevents cheating. The card should hang upon the wall so that the lower lines of type are level with the child's eyes, and children waiting to be tested should be so placed that they cannot see the card until their turn comes. In order to make possible comparison between the vision of different people, sight-testing is carried on at a standard distance of six metres (twenty feet) from the test card. Standing at this distance the child begins to read from the top of the card and the last line which he reads entirely correctly is noted. The result is then expressed as a fraction :

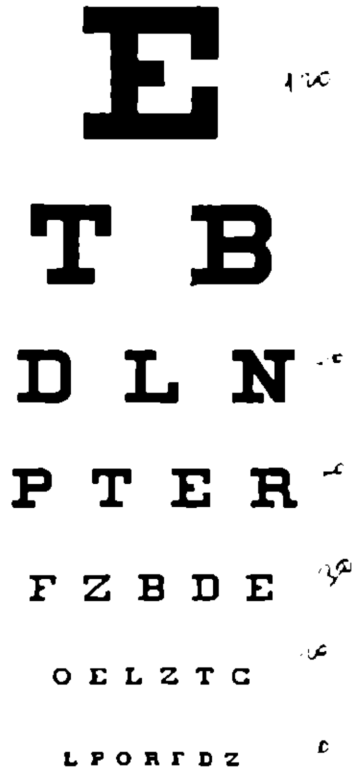


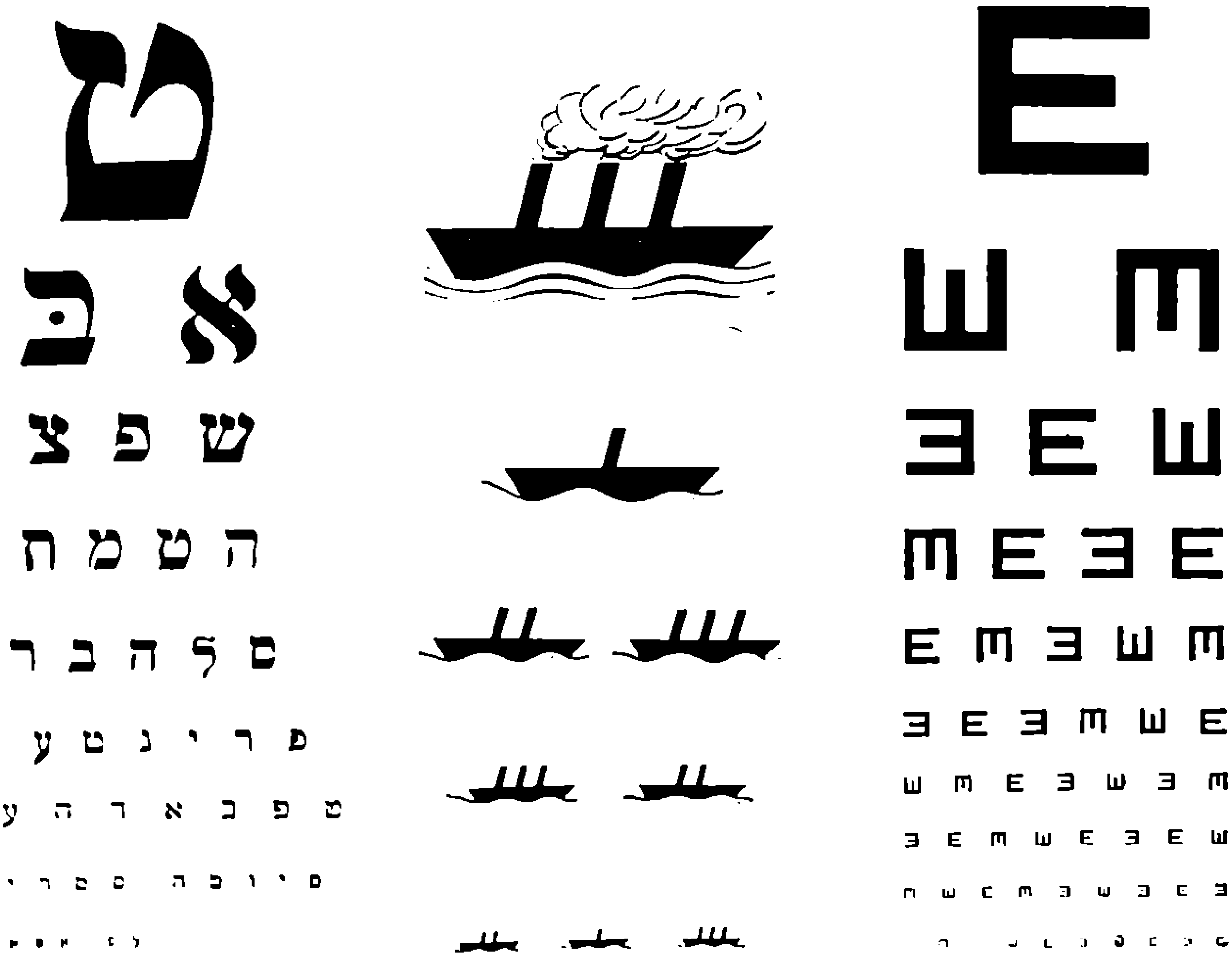
FIG. 96.—Snellen's test type.

$$\frac{\text{where the child stands}}{\text{what the child sees.}}$$

Thus, if a child, standing at six metres, reads all the card, including the six metre line, his fraction is $\frac{6}{6}$. This represents normal vision. If he is short-sighted he may not be able to read beyond one of the larger lines, intended to be read at twelve or perhaps twenty-four metres. The fraction in this case would be $\frac{6}{12}$ or $\frac{6}{24}$, representing short sight. Some eyes can see (at six metres) small print intended to be read at three metres (if this is provided on the card), giving a fraction of $\frac{6}{3}$. As the testing distance is always the same the numerator of the fraction is always six.

In certain cases other kinds of test type are employed (Fig. 97). If a child is not familiar with the alphabet (or if an adult is illiterate), Cohn's type may be used. This

consists of capital E's arranged in lines of diminishing size, like Snellen's type, but turned in different directions. By holding up three fingers the child can indicate the direction of the E at which he is looking and information about his vision can be obtained as before. Pictorial type may be used instead of Cohn's type, while Jewish type may be used for Jewish children.



Jewish type. Pictorial type. Cohn's type.

FIG. 97.—Test types.

DISORDERS OF THE EYE

Disorders of the eye may be conveniently divided into two categories. First, disorders of the optical mechanism : the eye does not focus satisfactorily, although it need not necessarily be diseased. Second, diseases in the usual sense of the word, irrespective of the presence or absence of a focussing defect. Focussing abnormalities will be considered first and then the commoner eye diseases.

Short Sight.—Fig. 98 shows an eye suffering from *short sight* or *myopia*. Superimposed upon this is the outline

of a normal eye for comparison. It will be seen that the short-sighted eyeball is too long from back to front. The lens, however, focusses rays of light where the retina ought to be if the eye were normal. As the retina of the short-sighted eye is too far back, vision is not clear. When the eye looks at a near object it receives diverging rays of light. These require a rather greater distance for focussing, and this, of course, suits the short-sighted eye. Therefore, when a person suffers from short sight he tends to hold

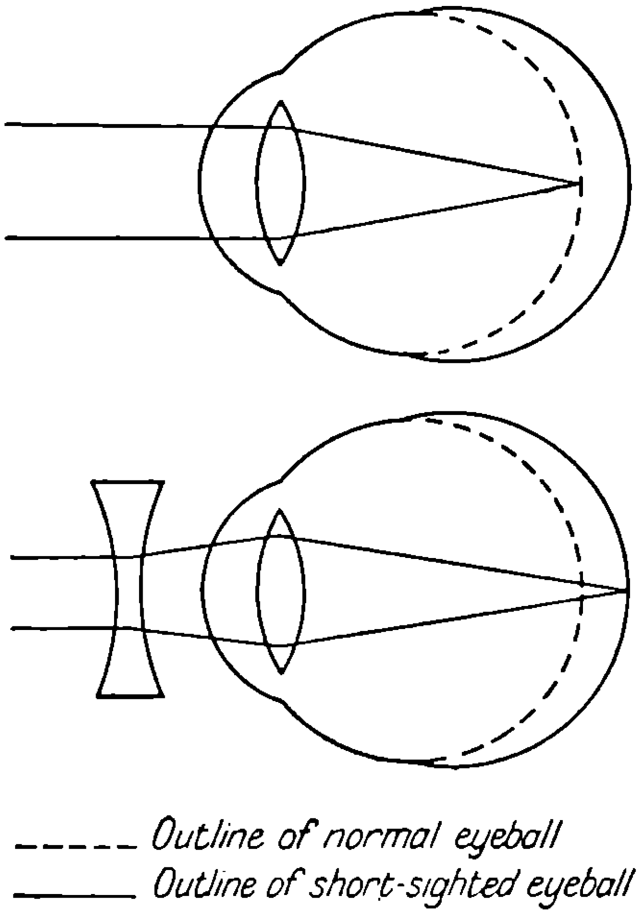


FIG. 98.—Short-sight and its correction.

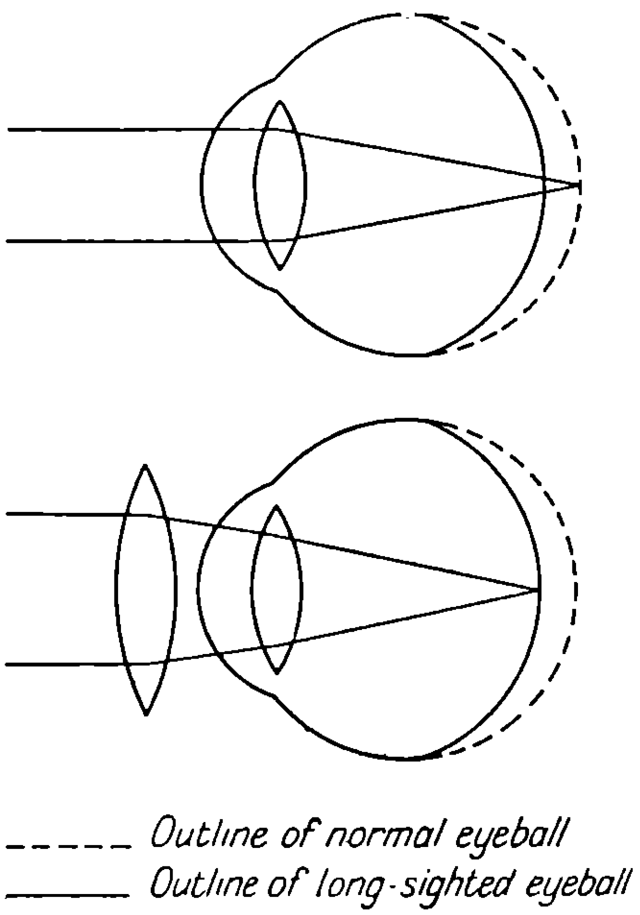


FIG. 99.—Long-sight and its correction.

objects close to his face in order to see them clearly, and when forced to look at a distant object (blackboard, wall chart) sees it only with difficulty. A short-sighted child may make mistakes in reading from the blackboard. Short sight is corrected by placing a concave spectacle lens in front of the eye. Such a lens converts parallel rays of light into diverging ones without the necessity for holding the object close to the eyes. In this way the short-sighted person is enabled to look at distant objects in comfort. Short sight is a complaint which tends to run in some families and in certain races.

Long Sight—In *long sight* or *hypermetropia* (Fig. 99) the eyeball is too short. Therefore rays of light are not focussed upon the retina, the lens attempting to focus them where the retina ought to be if the eye were normal. Long sight is corrected by a convex spectacle lens which bends rays of light together so that the lens of the eye has only to complete the convergence. The eye is thus able to effect a focus in a shorter distance, which is what is required. Without spectacles a long sighted person can never have converging rays of light entering his eye. From near objects the rays are divergent and so focussing is impossible : from distant objects the rays are only parallel and still not

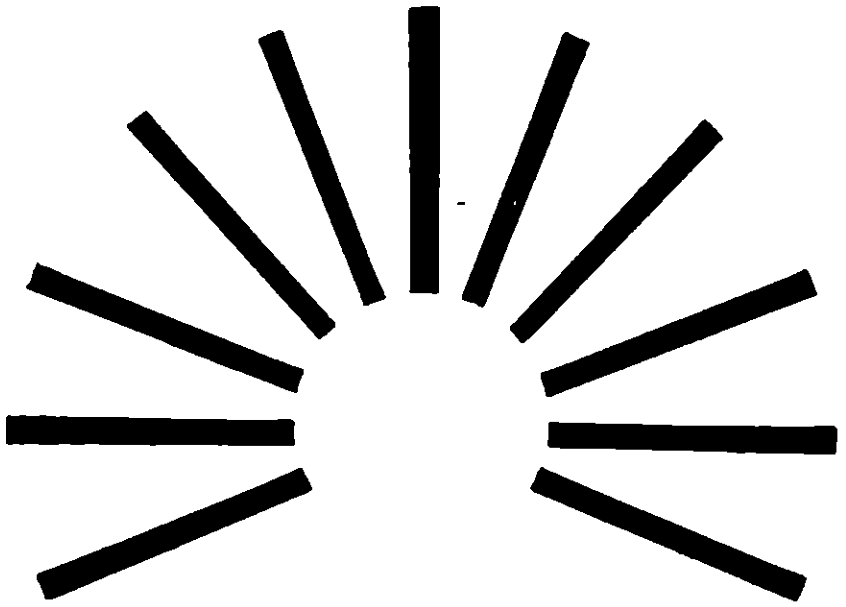


FIG. 100.—Test form for astigmatism.

convergent. A long-sighted child, therefore, has difficulty in all his school work, but particular difficulty in near work. Most eyes are long sighted at birth (eyeball too short). The eye then grows, along with the rest of the body, until the eyeball is of normal dimensions. If growth continues after this point, short sight results (eyeball too long).

Astigmatism.—Astigmatism is a condition in which the eyeball is irregularly shaped. It is not possible to represent this in a simple diagram. The irregularity naturally interferes with focussing, and the condition can often be detected by the use of a diagram like Fig. 100 but on a larger scale. Looking at such a diagram, the astigmatic eye

is able to focus the more vertical lines, but finds the horizontal lines somewhat blurred and out of focus. If the horizontal lines are in focus, the vertical ones are out of focus, and so on. There are, of course, more accurate ways of detecting astigmatism. The child with astigmatism cannot place his work in any position for satisfactory vision and the complaint requires correction by complex spectacle lenses.

Eye Strain.—Any of the foregoing conditions, if not corrected by spectacles, may give rise to eye strain. This is characterized by screwing up the eyes, frowning, the presence of headache and sometimes biliousness. Eye strain can also be caused by lack of attention to the points mentioned in the section on the hygiene of the eye. If a child presents symptoms of eye strain its vision should be tested by a competent person.

Squint.—In the complaint known as squint the eyes do not both look in the same direction. The most common variety of squint is that in which one eye looks inward towards the nose: convergent squint. More rarely one eye looks outwards (divergent squint), or even upwards or downwards. Squint may be due to some inequality in the pull of the external eye muscles, but is more commonly caused by a defect of vision. If one eye is long or short sighted, the information which it sends to the brain is not as valuable as that supplied by the other eye. The brain tends to disregard the abnormal eye and to rely upon the sound one. Eventually, the brain does not even trouble to turn the abnormal eye to look at the object of attention, and a squint results. An eye which is thus neglected tends to become more abnormal, vision in it being largely lost. Squint may require an operation for its correction, but sometimes the use of spectacles which correct the vision of the abnormal eye proves sufficient to do away with the squint. In recent years much work has been done upon the correction of squint by a process of re-education of the eyes. This is known as *orthoptic* treatment. In its simplest form it may involve covering the normal eye to

compel the brain to use and exercise the squinting eye. More complicated orthoptic treatment requires the use of complex and ingenious pieces of apparatus which it would be beyond the scope of this book to describe.

Eye Diseases.—There are many eye diseases (as opposed to focussing defects) which may affect children. Only four common ones will be discussed here.

Cataract.—In this disease the lens of the eye loses its transparency and tends to become opaque. The complaint is sometimes present from birth but may also be caused by certain general diseases and by injuries to the eye. The treatment is surgical removal of the opaque lens and the subsequent wearing of suitable spectacles to focus rays of light upon the retina.

Blepharitis.—Soreness of the margins of the eyelids is known as blepharitis or " sore eyes." The lids appear red and inflamed, and itch and smart. The inflammation is commonly due to infection of the lids by germs introduced by the child rubbing his eyes with dirty fingers. If the general health is low, as in an undernourished child, infection is more likely to occur. Blepharitis readily clears up if the eyes are bathed with boric acid lotion and anointed with boric acid ointment. The child is most likely to form the habit of rubbing the eyes if he suffers from eye strain, therefore repeated attacks of blepharitis indicate the necessity for testing the vision.

Stye.—A stye is a small abscess of one of the Meibomian glands and is much the same thing as a boil. Styes may occur in the same circumstances as blepharitis, but recurrent attacks are usually signs of low general health. Styes yield to the same treatment that was recommended for blepharitis, but the underlying cause of the condition should be sought for and removed.

Conjunctivitis.—This term means inflammation of the conjunctiva, the thin membrane covering the front of the eyeball. In health this transparent membrane is not

noticeable, but when suffering from injury or infection it becomes bloodshot. When infection is the cause of the bloodshot eye the term conjunctivitis or "pink eye" is applied. The complaint is marked by pain which is made worse when light enters the eye. A child suffering from pink eye therefore shields his eyes from the light. The affected eye runs with tears and pus, and on waking in the morning the eyelids may be stuck together. Some kinds of conjunctivitis are very infectious and dangerous to vision. If a child presents these symptoms it is not wise for a teacher to make any examination of the eye on account of the infectious nature of the disease. Infection is readily spread by such means as the common use of a roller towel. A child with conjunctivitis should have immediate treatment to preserve his vision and be kept away from school for the protection of other people.

A remedy which is commonly sold for the treatment of eye diseases is golden eye ointment. Although this ointment is valuable in some cases it is not wise to use it indiscriminately without medical advice. Medical advice should also be sought before an eye is bandaged up. In some infections bandaging the eye merely keeps the germs warm and protected and encourages them to go on with their work.

Education of Children with Defective Vision

In most cases defective vision can be corrected by the use of suitable spectacles. As long as the child is wearing his glasses he may be regarded as normal for all ordinary purposes. In some cases the visual defect is very marked, or is progressive, and makes it necessary to employ special methods of education. The children who require special education by virtue of defective vision may be divided into certain categories which will now be discussed.

Short-Sighted Children.—This group includes those children who can see normal school books but who should not be allowed to use such books on account of very marked short sight. Such children are best dealt with by placing

them in a special class : a *Myopic* or *Sight-Saving Class.* The second term is the better as it states the object of the class and excites less opposition from parents. If the class is attached to an ordinary school it avoids stigmatizing the children as peculiar and enables them to make contact with normal individuals to a considerable extent. It is sometimes found convenient, however, to have the Sight-Saving Class at a blind school.

These children require a certain amount of individual attention from the teacher so there should not be more than twenty in the class. Oral instruction plays a large part as no ordinary reading or writing can be done. Reading is carried out from large charts on the wall or from specially printed books with very large type. Writing can be done upon blackboards running round the walls of the room or each child may have a special desk, the lid of which reverses to form a blackboard. Writing is performed at arm's length in the style known as free-arm writing. No fine work such as sewing should be attempted but some kinds of handwork which do not require close attention from the eyes may be introduced. The children may be profitably taught some occupation which will be useful to them in earning a living later on (vocational training). The class-room should receive plenty of lighting, both day and artificial, and the children should be discouraged from doing unsuitable tasks in a bad light at home, especially reading newspapers—the worst kind of print for short-sighted eyes. The short-sighted children require frequent medical inspection, especially examination of the eyes to observe the progress of the condition.

There has been a tendency to eliminate so much of the ordinary school work in Sight-Saving Classes that the children have left school in a very unsatisfactory state of education. The modern view is that it is better to take some risks with the eyes to prevent this and it has been found that short-sighted children can do much more than was previously supposed without damage to their eyes.

Semi-Blind Children.—The semi-blind form a group falling between that just described and the next group,

the blind. If their defect is relatively slight they may be educated with the short-sighted children. If their defect is marked they should go along with the blind.

Blind Children.—This category includes not only the definitely blind, but all those children whose vision is so defective that they cannot see the print of ordinary school books. Education of the blind is compulsory between the ages of five and sixteen. In some circumstances blind children may attend day schools, but over the age of eleven a residential school is better, as they need, in addition to ordinary education, instruction in the management of their

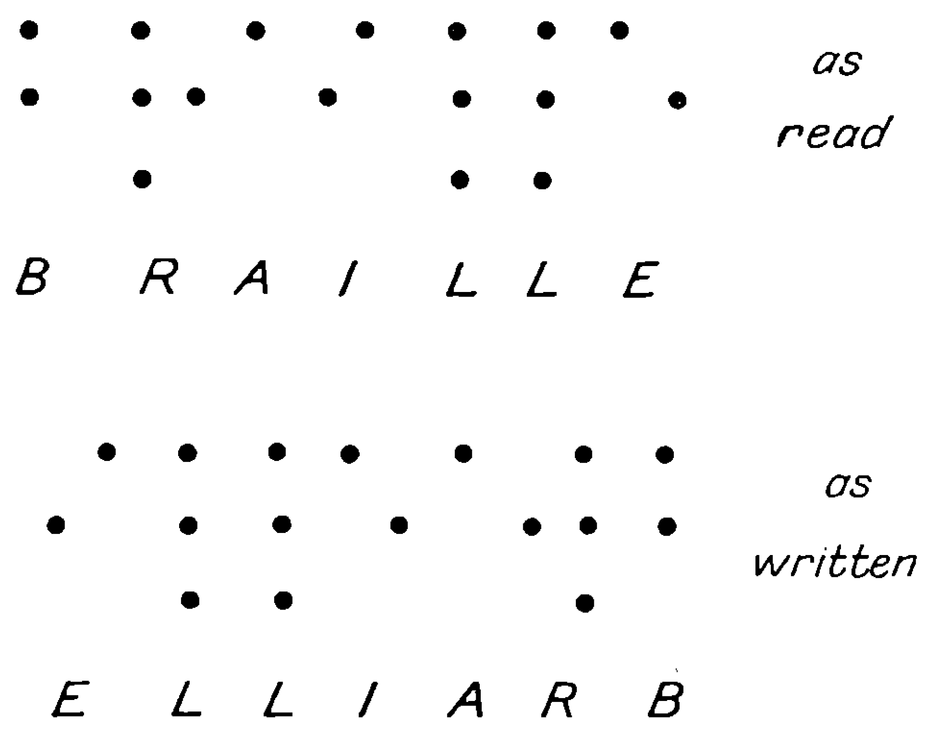


FIG. 101.—Braille.

everyday lives and vocational training to enable them to earn a living later in life.

Teachers of the blind need to be specially trained and the classes should be small with not more than twelve to fifteen children in each. For reading, the blind use the Braille system, named after the inventor, Louis Braille, who was himself blind. The letters of the alphabet are represented by raised dots upon stiff paper and are felt by the fingers passed lightly over the page. In writing, these dots are impressed upon soft paper by a blunt steel point, the hand being guided by a perforated ruler. A special Braille writing machine may also be employed. The dots

are impressed upon the paper so that they stand out on the opposite side and, in order that the letter may be read normally when the page is turned over, it must be written wrong way round. The blind child has to learn two alphabets, one for reading and one for writing (Fig. 101) and in addition there are various systems of shorthand or contracted Braille. Arithmetic is done by inserting rectangular

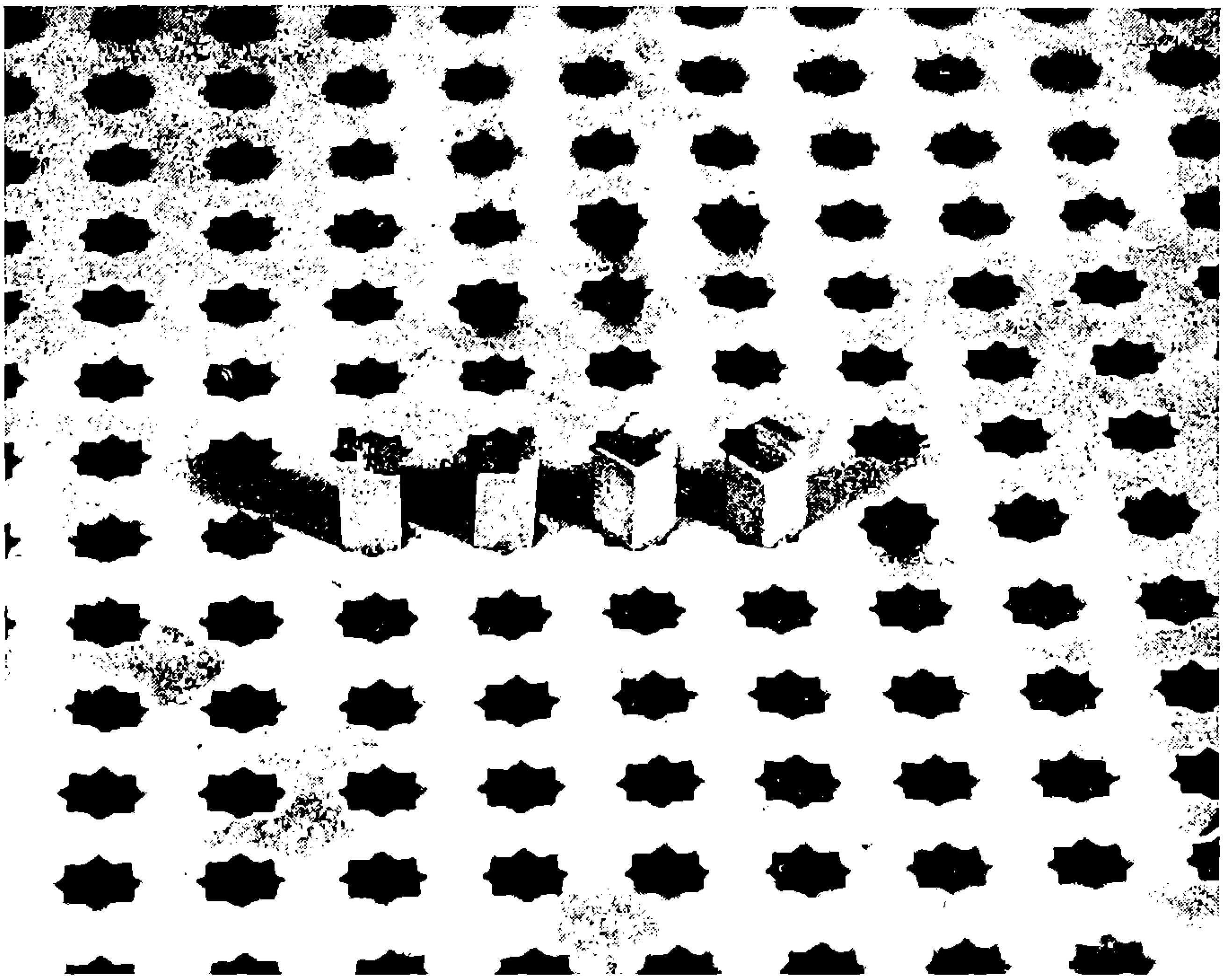


FIG. 102.—Blind calculating board (Taylor frame).

pegs into star-shaped holes in a board, different positions on the board and different positions of the same peg indicating the various figures (Fig. 102). Such subjects as geography and geometry lend themselves to treatment by means of relief maps and solid models. A blind slide rule is also available. Some ingenuity has to be exercised in devising a scheme of physical education for blind children, but with proper instruction and suitable aids they can be taught to swim, to run races and even to play cricket.

CHAPTER 21

THE EAR AND HEARING

LIKE the eye, the ear is a sense organ which is of great importance in education. A child has not merely to look at things in school, but has to listen to instruction. The ear is not only concerned with hearing: part of the organ is used to enable us to appreciate movement and the position of the body in relation to the Earth.

STRUCTURE OF THE EAR

The part of the ear (the *pinna*) visible on the outside of the head is relatively unimportant, being a mere trumpet

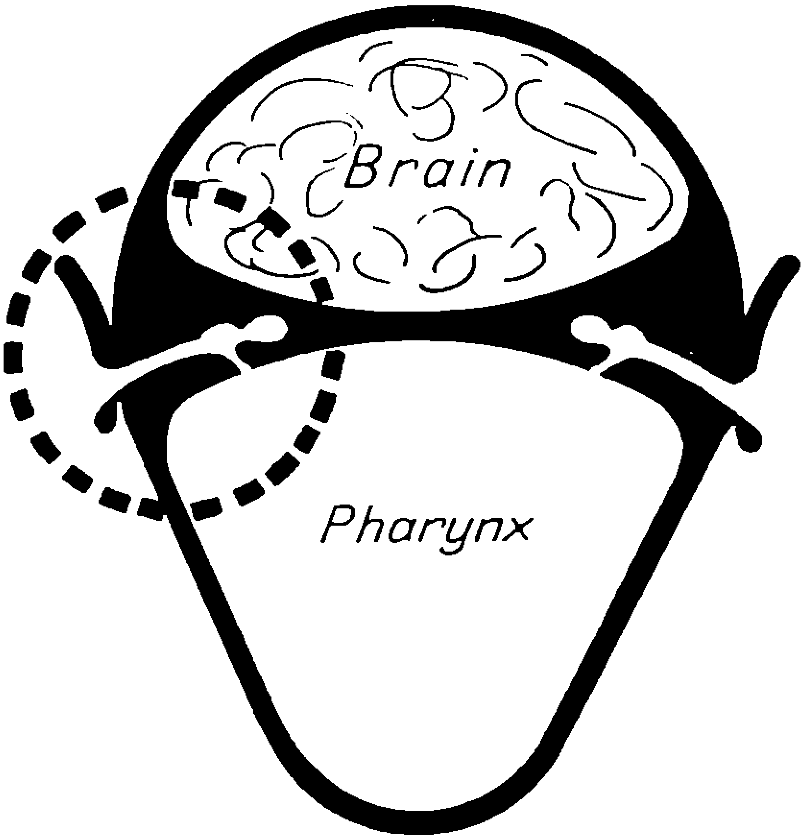


FIG. 103.—Section of the skull to show the position of the auditory apparatus. (The part within the dotted circle is represented on a larger scale in Fig. 104.)

for the collection of sound waves. The real organ of hearing is embedded in the bone of the skull. Fig. 103 shows a

section from side to side of the head in the region of the ears. This would pass behind the orbits and would expose two cavities of the head : the brain cavity above and the pharynx (behind the nose and mouth) below. The two cavities are divided by a plate of bone in which are certain passages or tunnels containing the auditory apparatus. The part of this diagram within the dotted circle is represented on a larger scale in Fig. 104. The two figures should

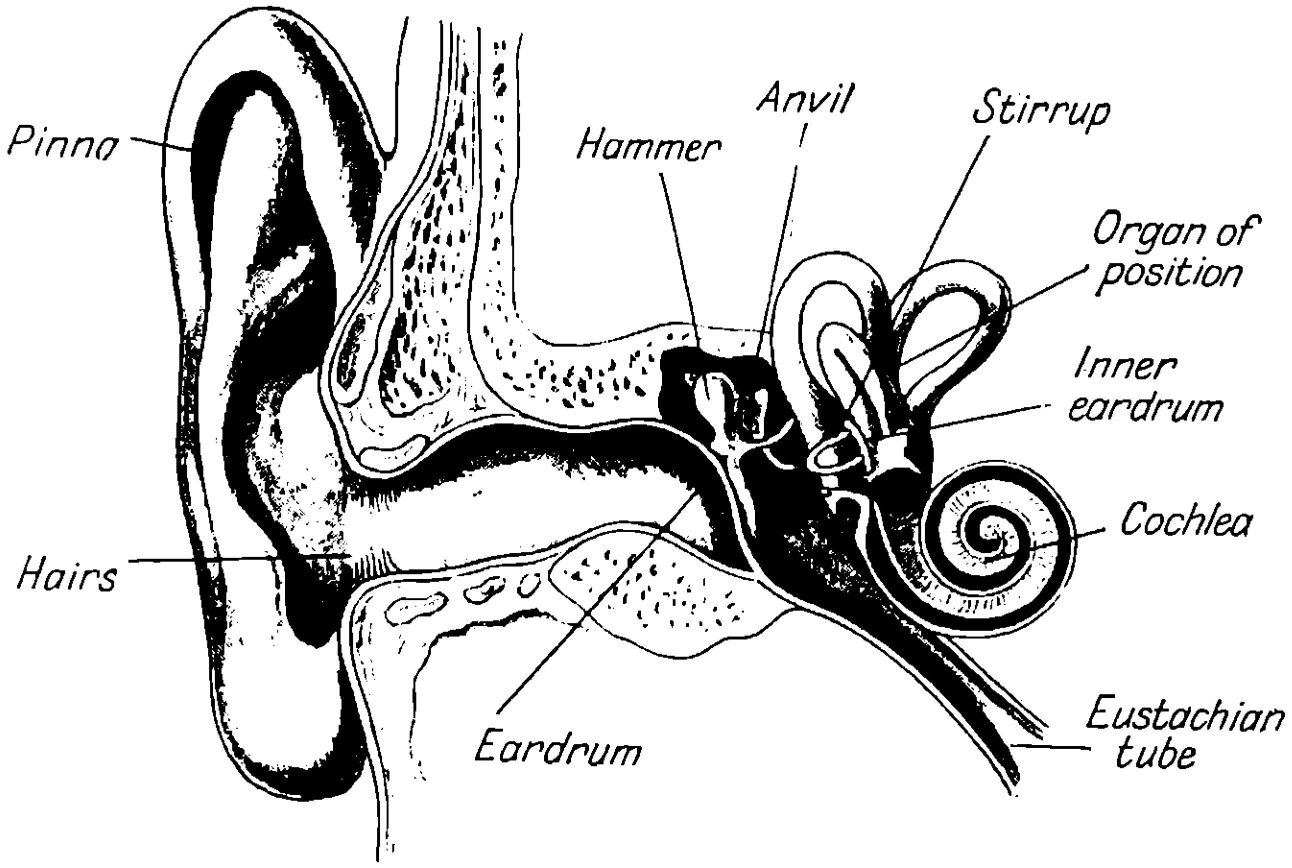


FIG. 104.—The structure of the ear (diagrammatic).

be used in conjunction with one another in following the description of the structure of the ear.

External Ear.—The pinna surrounds an opening in the side of the head which can be seen in the skull in Fig. 8. The opening leads to a short passage in the bone which extends inwards for rather more than an inch. This passage is lined by skin continuous with the skin over the outside of the face. At the entrance to the passage there is a number of short, stiff hairs which serve to keep out insects and other foreign bodies—a matter of importance to many lower animals though not, perhaps, to man. The skin of the passage contains glands, much like ordinary

sebaceous glands, which produce a fairly stiff wax. The wax, like the hairs, is a protection against the entrance of unwelcome visitors. The far end of the passage is closed off by a thin, circular membrane, the ear drum. In appearance and texture the drum of the ear resembles an ordinary drumhead on a small scale. All the structures which have been described down to the ear drum constitute the external ear.

Middle Ear.—Beyond the ear drum is a small cavity in the bone called the middle ear. A passage, the *Eustachian*

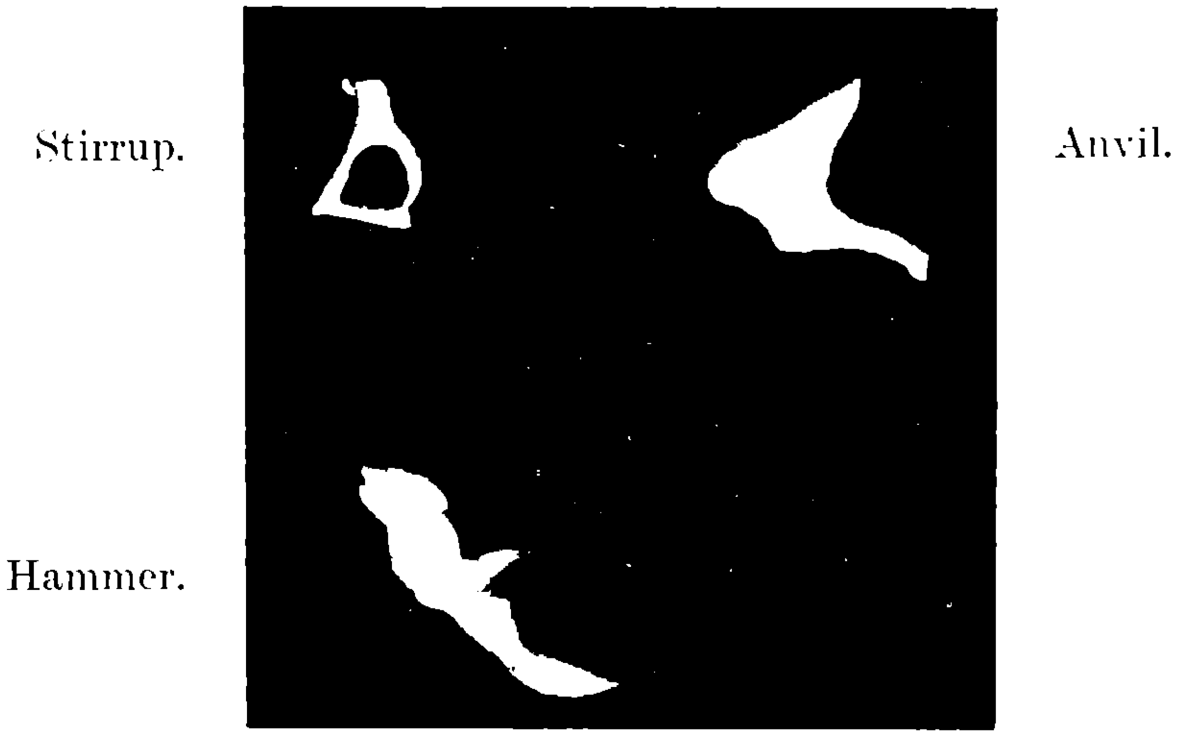


FIG. 105.—The bones of the middle ear.

tube (after Eustachius who discovered it) leads from the middle ear to the pharynx. Air flows into the passage of the external ear and exerts pressure upon the ear drum. To prevent damage to the drum, this pressure must be balanced in the middle ear by air which flows up the Eustachian tube from the nose and mouth. If you have a bad cold with the nose full of sticky secretion it blocks up the lower end of the Eustachian tube, preventing the entrance of air and impeding the work of the ear drum. This gives rise to the temporary deafness which is commonly associated with a cold in the head. The middle ear contains three small bones (Fig. 105) which are suspended from the

walls and roof of the cavity by ligaments. On account of their shapes they are known as the *hammer*, the *anvil* and the *stirrup*. The handle of the hammer is firmly attached to the ear drum and its head is in contact with the anvil, which in turn is connected to the stirrup. The middle ear communicates through a small opening with the internal ear. A membrane stretched across this opening forms the inner ear drum, and against this drum the base of the stirrup rests.

Internal Ear.—The internal ear consists of two parts. One part is the *organ of position* (the three loops in Fig. 104) and will be described later. The other part, concerned with hearing, is a spiral passage in the bone of the skull known as the *cochlea* (Latin, a snail shell). The cochlea communicates with the middle ear through the small opening, already described, which is closed by the inner ear drum. Further details of the cochlea are given in the next section.

FUNCTION OF THE EAR

Nature of Sound.—In order to understand how the ear works, it is necessary to know something of the nature of sound. If a stone is thrown into a pond it produces a disturbance in the water which gives rise to ripples. The ripples travel in circular form to the edge of the pond, where they die away (Fig. 106). If a toy boat is floating on the pond it rocks to and fro as each ripple passes under it. If you lie on the ground so that you cannot see the the water in the pond you can tell when ripples are disturbing the surface by watching the mast of the boat and observing when it moves. In other words, the presence of waves can be detected, even when the waves are invisible, if a suitable indicating instrument is employed. In some respects the air resembles water. A disturbance (clapping the hands, speaking, playing a musical instrument) creates waves which can be detected although they are invisible. The drum of the ear is a device for the detection of such sound waves.

Mechanism of Hearing.—Sound waves enter the passage of the external ear and pass down to the drum, making it vibrate to and fro. It will be recalled that the handle of the hammer bone is in contact with the inner side of the ear drum. This bone is therefore set in motion and in turn agitates the anvil, which transmits the movement to the stirrup. The stirrup is in contact with the internal ear drum to which the movement is finally transferred. The inner ear drum closes the end of the spiral passage of the cochlea, as has already been explained. This passage contains a clear, watery liquid much like ordinary lymph.

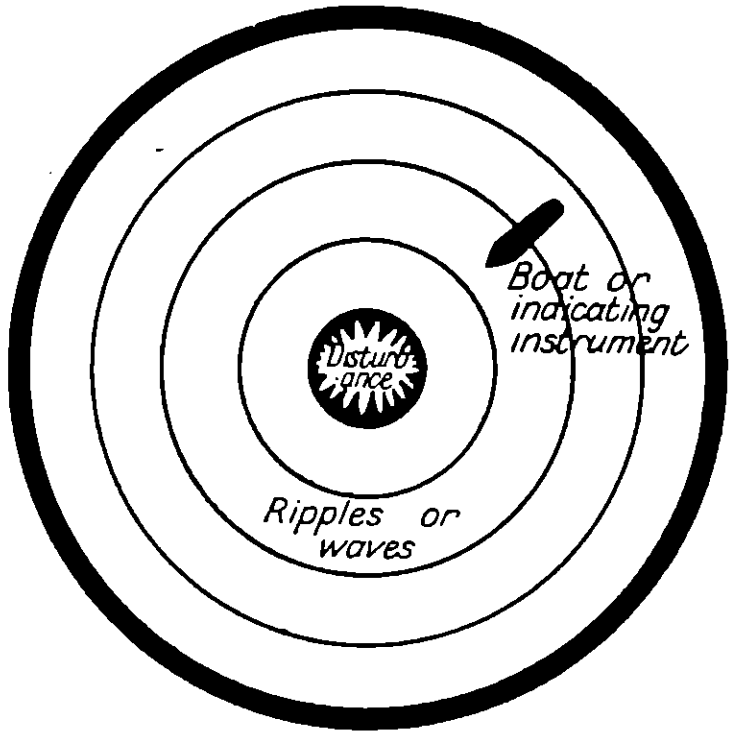


FIG. 106.—Wave production.

The vibrations of the inner ear drum set up waves in this liquid. The sequence of events is therefore sound waves agitating the outer ear drum, movement transmitted from the outer to the inner ear drum by the chain of small bones in the middle ear and the final conversion of this movement into waves in the liquid contained in the cochlea. The nerve of hearing (*auditory nerve*) terminates in the cochlea, the actual nerve endings projecting into the liquid in this spiral passage. As waves travel along the liquid they agitate the nerve endings, giving rise to nerve impulses which travel to the brain and are there interpreted as sounds heard. The auditory nerve endings vary in size,

different nerve endings being affected by different sizes of wave. In this way we are able to distinguish a considerable range of sounds. There are some sounds of high pitch which we cannot hear, as the cochlea contains no nerve ending appropriate for these. Other animals (the cat, for example) are able to hear sounds which are outside the range of the human ear.

Sense of Position.—Fig. 107 shows the various parts of the internal ear detached from their surroundings. The cochlea can be seen and its opening which in life is covered by the inner ear drum. The other structures are concerned with the appreciation of movement and position. Even if the eyes are closed so that surrounding objects cannot be seen we are still aware of whether we are standing on the head or the heels ; whether we are moving forwards or backwards, and so on. We know the position of the body without comparing it with anything in the outside world.

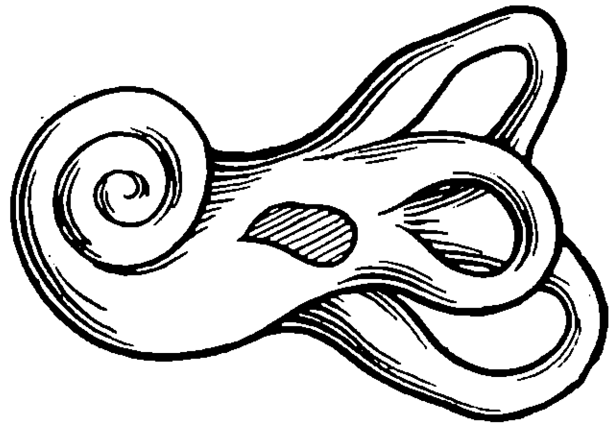


Fig. 107.—The internal ear.

Recognition of Position.—In the internal ear are two small spaces containing some loose specks of bone (Fig. 108). Nerve endings project into these spaces. When the body is upright the specks of bone, acting under the influence of gravity, press upon some of these nerve endings, giving rise to impulses which cause the brain to recognize that the body is right-side up. If a person stands on his head the specks of bone naturally come to rest upon other nerve endings, giving rise to impulses which inform the brain of the altered position. The same mechanism operates for any position which the body assumes.

Recognition of movement.—The foregoing description relates to the recognition of position only when the position has been adopted : the organs involved do not inform the

brain of movement while it is actually taking place. For this another device is necessary. The three looped portions

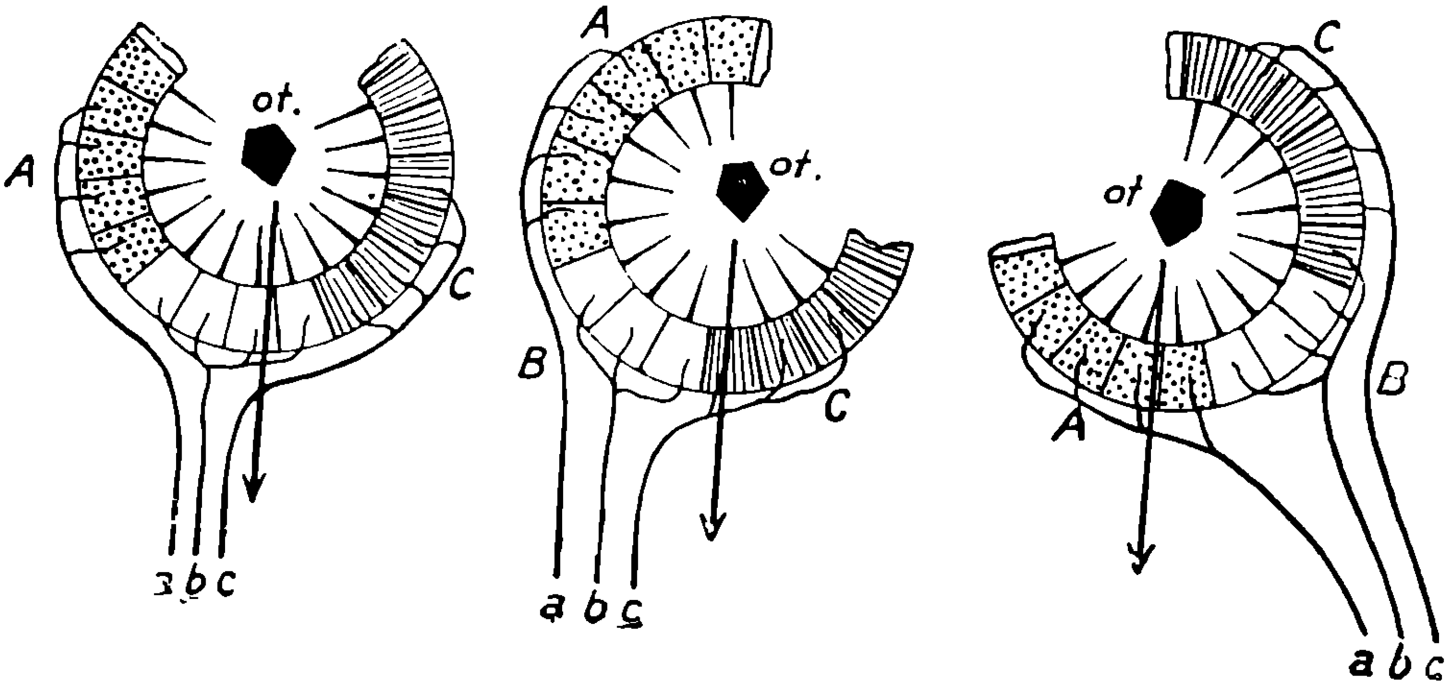


FIG. 108.—Position determining organs (greatly simplified).
A, B, C. Endings of nerves.
a, b, c. Nerves.
ot. Speck of bone resting on nerve endings.
→ Pull of gravity.
(By permission from Lovatt Evans, *Starling's Principles of Human Physiology.* Churchill.)

of the internal ear shown in Figs. 104 and 107 are tubes, known as the *semicircular canals*, arranged in planes at right angles to one another. Like the passage of the cochlea these canals contain liquid with nerve endings projecting into it. Fig. 109 represents one semicircular canal (the vertical one) detached from its fellows. The swelling at one end contains the nerve endings. If the owner of this canal turns head over heels (forwards) his semicircular canal turns with him as shown by the large arrow. The fluid within the canal tends to be left behind, as it were, and piles up at one end as shown by the small arrow. The pressure

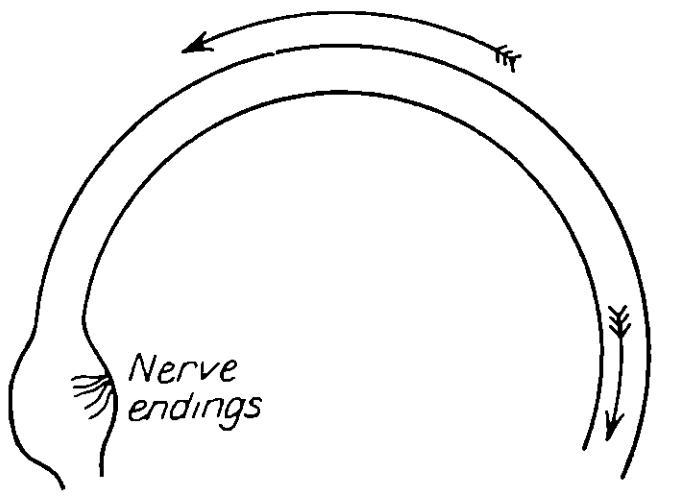


FIG. 109.—Diagram of semicircular canal.

of fluid is thus increased at one end of the canal and decreased at the other. Such changes in pressure are detected by the nerve endings projecting into the fluid and appropriate messages are sent to the brain informing it of the state of affairs. Between them the semicircular canals are able to detect movement in any direction. It is a familiar experience that if you spin round and round rapidly and suddenly stop you have an illusion that you are now spinning in the reverse direction. This is due to a disturbance of the fluid in the horizontal semicircular canals. While you are rotating the fluid is piled up at one end of the canal but on checking the motion the fluid rebounds to the other end giving rise to the illusion in question.

Hygiene of the Ear

From some points of view the possession of good hearing is of more importance than the possession of good vision. Defective sight can usually be corrected by spectacles, and while wearing appropriate spectacles a person is normal for all practical purposes. No satisfactory correction is generally possible for imperfect hearing, and so it is particularly important to preserve the hearing of children during school life.

Maintaining Normal Hearing.—The maintenance of normal hearing means simply the avoidance of certain harmful things : it is a negative rather than a positive matter. Each part of the ear must be considered in turn. The outer ear may be blocked by material in the passage leading to the drum. If this is wax it must be removed by syringing carried out by a skilled person. Obstruction due to a foreign body is avoided by not inserting foreign bodies. The drum may be damaged by objects poked into the ear, often with the idea of cleaning out wax. All such objects, even the corner of a soft towel, may cause damage if used vigorously upon the ear of a child. Hard objects, such as hairpins, are obviously dangerous. Boxing the ear may

damage the drum simply by forcing some ordinary atmosphere violently down the passage, when it acts like anything else poked into the ear. The middle ear may become diseased owing to the spread of infection from the throat along the Eustachian tube. This may be avoided by attention to the hygiene of the nose, throat and teeth. Disease of the middle ear may also involve the drum. Long continued, high-pitched sounds may damage the internal ear by fatiguing some of the nerve endings, but children are not likely to be submitted to such experiences.

Tests of Hearing. ***Audiometer.***—Tests of hearing are less exact than tests of vision. The most accurate method of testing is by means of the audiometer. This is a gramophone with a number of sets of headphones so that many children can be tested at once. The machine plays special records which reproduce a voice speaking a series of numbers in gradually diminishing tones. Each child writes down all that he hears and, since the same record can be used in any part of the country, it forms a satisfactory standardized test. The audiometer is an expensive piece of apparatus and simpler methods of testing are commonly used in schools.

The watch test.—If the examiner has normal hearing children may be tested by their ability to hear the ticking of a watch compared with the examiner's ability to hear the same watch. The results are expressed as a fraction for each ear, the numerator being the distance in inches at which the child hears the watch and the denominator the distance in inches at which the examiner hears it. If the examiner can hear the ticking at twenty-four inches and the child only at twelve inches the fraction would be $\frac{12}{24}$, that is one-half normal hearing.

Forced whisper test.—As the most important noise to which a child has to listen is the teacher's voice, the ability to hear the human voice is the most satisfactory test of hearing. The best of the tests which do not require special apparatus is that known as the forced whisper

test. A forced whisper is one emitted after emptying the lungs of air as completely as possible, the resulting sound being less variable from person to person than is the ordinary speaking voice. In testing the hearing by this method each ear should be tested separately, the ear not in use being covered by several thicknesses of towel or clean cloth preferably held in place by a teacher or other responsible person and not by the child himself. It is not desirable to let the child plug his ear by inserting his finger into it, as this gives rise to a certain amount of buzzing in the head which interferes with the hearing of the other ear. The room in which the test is carried out should be large and perfectly quiet and not overlooking a busy road along which noisy traffic is liable to pass. The tester should stand at the side of the child opposite the ear to be tested and where the child cannot see the lips, as lip reading, even though performed unconsciously, would vitiate the test. Disconnected words, or numbers not in their usual order, should be employed in preference to formal sentences. This is to prevent the child's guessing the sentence from hearing one or two leading words.

Standards of Hearing.—Table XV shows different grades of hearing, based upon ability to hear the forced

TABLE XV.—Grades of Hearing

Feet.	*Group.*	*Comment.*
70-60	Average.	
60-20	Slightly hard of hearing.	Can hear teacher's voice. Not likely to be backward.
20-3	Moderately hard of hearing.	Many are backward.
Under 3	Semi-Deaf.	Not suitable for ordinary class.

whisper at certain distances. A child with average hearing hears the whisper at a considerable distance, up to sixty

or seventy feet. A child who is slightly hard of hearing will have a lower limit than this, anything down to twenty feet. Such a child, however, can hear the teacher's normal speaking voice quite satisfactorily, and is not likely to be backward on account of the slight defect in his hearing. Children with a limit of twenty down to three feet are described as moderately hard of hearing. They hear the ordinary speaking voice at a greater distance than three feet, of course, but many of them tend to be backward in school simply on account of their defect. Those children who can only hear the forced whisper at a distance less than three feet are termed the semi-deaf, and are not suitable for education in an ordinary class.

The "six-foot" rule.—In practice it is not important to assign a child to any of the grades listed in the Table: all that is required is to decide whether he should remain in the ordinary school or be educated in a special class. Those in the first two groups (average and slightly hard of hearing) are suitable for normal education. Those in the last group (semi-deaf) need special education. It is in the third group (moderately hard of hearing) that the dividing line occurs. These children have a limit for the forced whisper between twenty and three feet. Those round about twenty feet will not suffer in the ordinary school, but those round about three feet will tend to be backward. A convenient division is made by applying the "Six-foot" Rule which states that *if a child cannot hear a forced whisper with at least one ear at a distance of six feet he is not suitable for education in an ordinary class.*

Disorders of the Ear

For purposes of description, disorders of the ear may be divided into two groups: disorders of the auditory mechanism (degrees of deafness) and diseases in the usual sense of the word. This corresponds to the division that was made in the case of the eye. It will be recalled that a focussing defect could exist in a perfectly healthy eye, and that a diseased eye might be free from any error of focussing.

In the ear the division is not so complete as any disease is likely to give rise to deafness, and any degree of deafness is likely to be caused by some definite disease. Nevertheless, it is simpler to consider the two matters separately.

Deafness.—Deafness may be due to causes operating in any one of five situations: the external ear, the middle ear, the internal ear, the auditory nerve connecting the ear with the brain, or the interpreting centre of the brain itself.

External ear deafness.—Deafness may arise as a result of obstruction in the passage of the external ear. Such obstruction is caused by an accumulation of wax or by the introduction of a foreign body. Usually shouting overcomes deafness of this type, as the more vigorous sound waves are able to get past the obstruction. Raising the voice does not generally overcome deafness due to any other cause.

Middle ear deafness.—Disease of the middle ear (described later) may lead to damage or destruction of the three small bones and so deafness will result. These bones may also be injured or destroyed in a radical surgical operation necessary for the treatment of neglected ear disease. Middle ear disease may spread outwards and involve the outer ear drum, or the drum may be damaged by a foreign body introduced through the external ear. In either case, some degree of deafness is likely to arise.

Internal ear deafness.—The nerve endings in the cochlea are rarely affected by disease, but some of them may be so fatigued by continual over-use in listening to high-pitched notes that partial deafness results. This is not likely to occur in children, however. In some individuals the internal ear may be imperfectly formed and then deafness is present from birth.

Nerve deafness.—If the auditory nerve is diseased or injured in an accident involving the head, deafness is liable to occur. In this case, the ear and the brain are like two people attempting to telephone to one another when

the telephone wires have been cut: the ear itself being healthy in all its parts but unable to communicate with the brain.

Brain deafness.—Although the ear receives sound waves and nerve impulses travel along the auditory nerve, the final act of hearing is the interpretation of these nerve impulses by the auditory centre of the brain. If this part of the brain is out of action for any reason, hearing is impossible. Injury or some brain diseases may affect the auditory centre, or it may be imperfect as a result of general undevelopment of the brain such as occurs in some idiots.

Word deafness.—Children are occasionally found who, although not deaf in the ordinary sense, cannot appreciate any meaning in spoken words: they hear sounds, but meaningless sounds. This condition may arise in two ways. The person concerned may have limited powers of aural perception, all sounds appearing very much alike so that different words lack the distinctive quality by which ordinary people recognize them. Word deafness may also arise as a result of injury to the brain which interferes with this organ's power of associating sound and meaning. Children afflicted in this way naturally require special education if they are to overcome their disability to any extent.

General Ear Diseases.—Both the pinna and passage of the external ear are covered by skin, and consequently they are liable to ordinary affections of the skin such as boils or eczema. There is no need to deal with these complaints at this point. The internal ear is very rarely affected by disease, so that this also requires no mention.

Middle ear disease.—The middle ear, unlike the other parts, is commonly affected by serious disease. The term middle ear disease (used without qualification) always means an infection of this part of the ear by germs, with resulting inflammation. The germs generally reach the middle ear along the Eustachian tube from the throat, and the inflammation which they cause gives rise to the forma-

tion of pus or matter in the middle ear cavity. Swelling of the upper end of the Eustachian tube prevents the egress of pus along this passage and, as more and more pus is produced, increasing pressure is set up in the middle ear. This causes very severe earache, an important symptom in this complaint. Eventually, the pressure becomes so great that the pus bursts a way out through the ear drum, giving rise to a discharging ear. When the discharge begins the earache ceases because the pressure has been relieved. Quite commonly parents place a plug of cotton wool in a child's ear to absorb the discharge and consider that the disease is getting better as the pain has disappeared. The cessation of pain, however, indicates that the complaint has got worse rather than better. Neglected middle ear disease is dangerous for three reasons. When the pus bursts through the ear drum it may do considerable damage so that a permanent hole in the drum results. Sometimes the pus soaks through the thin bony roof of the middle ear and reaches the brain, often with fatal results. In either case the three small bones of the middle ear are liable to be damaged or destroyed with resulting interference with hearing. It is important that middle ear disease should be recognized and treated early, and any case of violent earache followed by a discharge should be regarded with suspicion. Sometimes these symptoms indicate nothing worse than a boil in the external ear, but it is better to send the unimportant boil to the school clinic rather than to fail to send the very important middle ear disease. The treatment of this complaint usually involves making an incision in the ear drum to allow the pus to escape. The opening which the surgeon makes in this way has clean-cut edges and is made in a selected region of the drum ; consequently it readily heals up. The opening made by Nature, if the pus is left to burst its way out, has ragged edges and may occur in an awkward part of the ear drum. It rarely heals up. If treatment is left until very late in the disease a more extensive operation may be necessary and this in itself is likely to cause deafness even if the middle ear disease is cured.

Education of Children with Defective Hearing.

Children who are deaf are commonly dumb as well. This is not due to any defect of the vocal organs but occurs simply because they have never heard speech and cannot imagine what it is like. In many cases it is possible to teach these children to speak by suitable educational methods and this should always be attempted. Those deaf children who are mentally normal should also be taught lip reading. If this is acquired early in life a high degree of proficiency may be attained, and this very largely mitigates the complaint of deafness as the lip reader is able to manage very well in all ordinary conversations. Those children who are sufficiently deaf to require special education may be divided into different categories according to their particular needs.

Hard of Hearing Children.—The hard of hearing are those to whom the six-foot rule applies. They are suitable for education in a special class, which may be attached to an ordinary school although in the charge of a specially trained teacher. If this can be arranged, the hard of hearing children are able to mix with normal children for many lessons and the disadvantages of complete segregation are avoided. For economic or other reasons the "hard of hearing class" may be held at a special institution in some areas. In any case the class should be small in numbers (not more than a dozen) on account of the individual attention which the deaf children require. As already mentioned, lip reading will be the basis of the teaching.

Semi-deaf Children.—The semi-deaf are those who cannot hear a forced whisper at a distance of three feet. Their education differs according to the degree of their disability. The slighter cases can be placed in the hard of hearing class, but the greater degrees of deafness may be considered to fall in the next category.

Very Deaf Children.—The very deaf includes those who are stone deaf and those who have a little hearing, though not sufficient for any practical purpose. Children

in this category are best educated in special schools. A day school may be suitable while they are young, but later a residential school is desirable where they may have vocational training to enable them to take up some suitable occupation which will make them more or less self-supporting in after life. These children require to be taught lip reading and, in some cases, speaking. Otherwise they take ordinary primary school subjects but are grouped in small classes of ten or a dozen, for obvious reasons. Those children who are dumb require physical training, games and breathing exercises designed to exercise their chests and to expand their lungs. Without this special attention they tend to lack chest development as they do not shout and chatter, when they play, like ordinary children.

Mentally Defective Deaf.—The mentally defective deaf need to be placed in special institutions for life, more on account of the mental defect than the deafness. Ordinary education is out of the question and lip reading is generally beyond them. They may be taught to make simple signs in order to communicate their wants to their attendants. They are, of course, outside the purview of the educational system.

In England, Local Education Authorities are bound by law to provide special education for deaf children.

CHAPTER 22

THE TEETH

THE teeth are organs of the digestive system but they play such an important part in the health of the body as a whole that they are considered here apart from the rest of the digestive system. Unlike most of the organs of the body the teeth are readily visible and so children are more likely to be interested, and to benefit from instruction, in dental hygiene than in instruction about those parts of the body which are beyond their vision. Moreover, knowledge concerning the teeth can be put to practical application in caring for these organs, whereas knowledge of the heart or kidneys is of very little practical utility to a child. The structure of the teeth will be described before considering the methods of preserving them in health.

STRUCTURE AND DEVELOPMENT OF THE TEETH

Structure.—Fig. 110 shows a tooth in section. The main mass of the tooth is made of a substance called *dentine* which is somewhat like bone but rather harder. Although dentine is hard it is not sufficiently hard to withstand the continual wear and tear of chewing the food. Therefore, the part of the tooth projecting into the cavity of the mouth is covered by still harder material, *enamel*, The layer of enamel is what is seen on looking at the teeth through a mirror. The part of the tooth which is embedded in the socket in the jaw-bone is covered by material known as *cement.* In appearance this resembles ordinary cement and serves to fasten the tooth firmly in its socket. The interior of the tooth is hollow, but in life this cavity is filled with soft flesh known as the *pulp* of the tooth. The

pulp contains blood vessels and nerves and so is the living, sensitive part of the tooth. The nerves and blood vessels enter the pulp cavity through the root of the tooth as can be seen in the figure. The part of the tooth which projects into the mouth is known as the *crown* : the part embedded in the jawbone is known as the *root*. The *neck* is the region where crown and root meet and this is the place where the tooth emerges from the gum. At the neck enamel gives place to cement, and the junction of

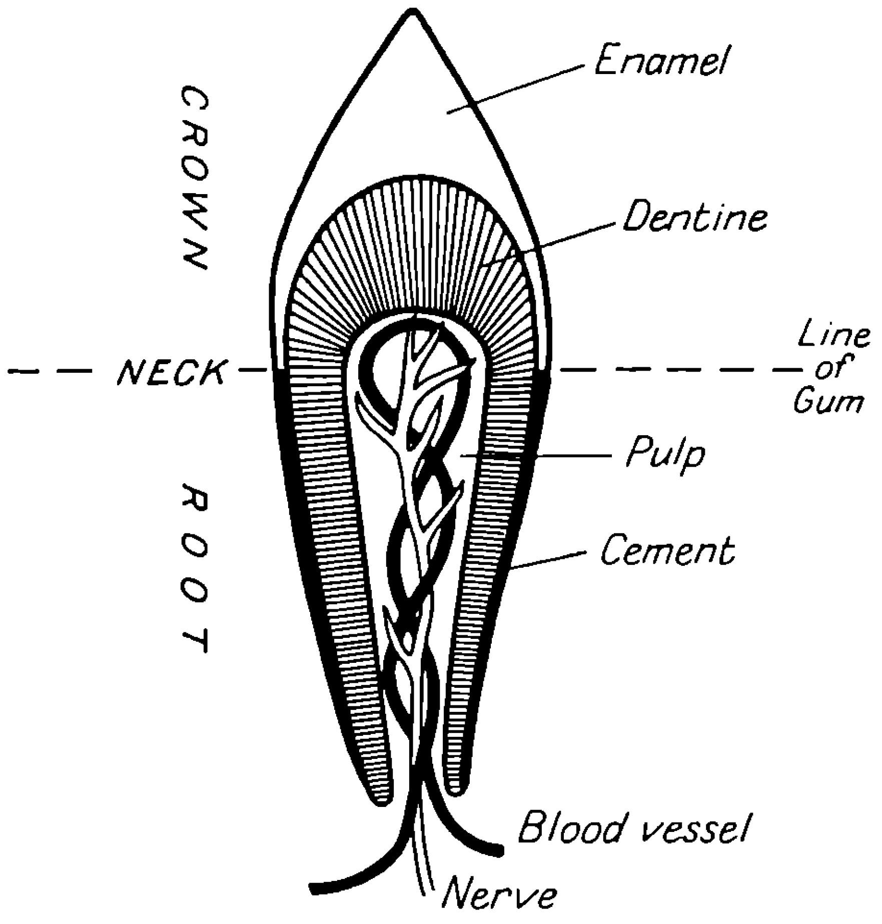


FIG. 110.—The structure of a tooth.

these two substances is a point of danger as germs may penetrate here right down to the dentine.

Types of Tooth.—Fig. 111 shows the teeth in position in the jaws. It will be seen that the teeth are not all alike. Those at the front (in each jaw) are flat, chisel-shaped teeth, designed for biting off pieces of food. Those at the back are broad and massive and are used to grind up the food. In between are teeth of intermediate form.

Sets of Teeth.—At birth no teeth are visible in the mouth of a child. They are present, however, beneath

the gums as will be explained later. During infancy a set of small teeth appear, and in later childhood give place to more numerous and more massive teeth which last into adult life. There are thus two sets of teeth in a normal individual.

Temporary teeth.—The first teeth are known as the temporary, deciduous or milk teeth. They are represented in Fig. 112. The complete set numbers twenty teeth,

FIG. 111.—The (temporary) teeth (by permission of the Dental Board of the United Kingdom).

that is ten in each jaw. It is simplest to consider half a jaw beginning in front and taking each tooth in turn to the back. At the front of the half-jaw are two cutting teeth, the *incisors*, which appear about the age of six months. Next comes a somewhat pointed tooth, the *canine* or dog tooth (sometimes called the *eye tooth*). This corresponds to the prominent fang which is apparent in the jaw of the dog and some other animals. Behind the canine are two grinding teeth, the *milk molars*, the last of which comes through the gum about the end of the

second year of life, thus completing the temporary teeth. This set of teeth suffices for the child until about the age

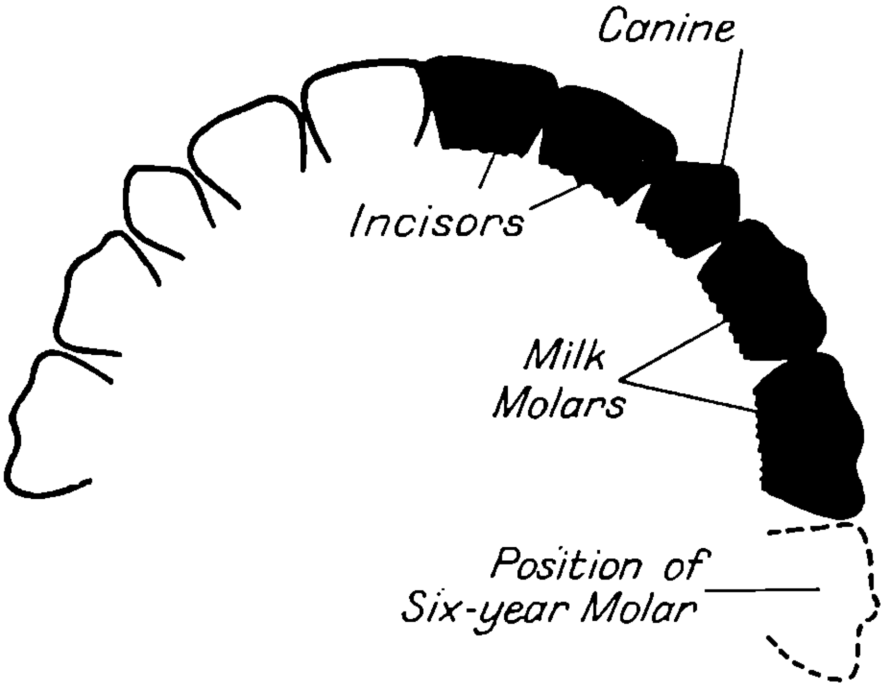


FIG. 112.—The temporary teeth (diagrammatic).

of six years when the first of the permanent teeth makes its appearance.

Permanent teeth.—The first permanent tooth is the *six-year molar* (so called on account of the age at which it

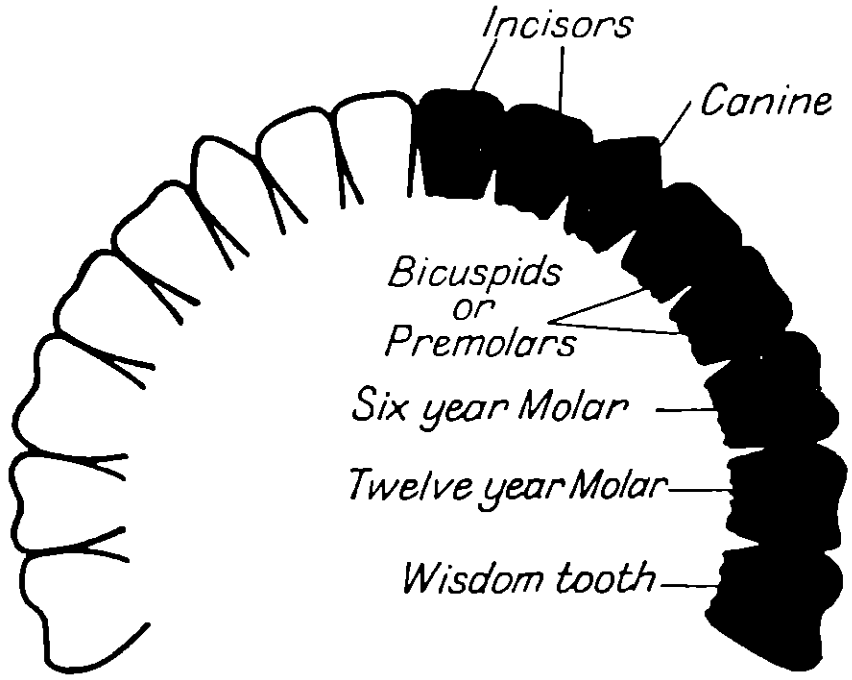


FIG. 113.—The permanent teeth (diagrammatic).

comes through the gum) which appears behind the last milk molar before any of the temporary teeth have been lost. The four six-year molars provide the child with grinding surfaces which serve him during the period when

he is exchanging his temporary for permanent teeth. These four teeth are extremely important for if they come through crookedly, or if they are allowed to decay, the jaw may fail to grow properly to accommodate the permanent teeth. They have been called "the key-stones of the dental arch" because of the part they play in deciding the form of the adult jaw. After the six-year molars have appeared the temporary teeth become loose and either fall out or are easily extracted to make way for the permanent teeth. The permanent teeth are shown in Fig. 113, and will be described in one half of the jaw as before. In front are two incisors and a canine replacing those of the temporary set. Behind the canine, in the position occupied by the milk molars, are two grinding teeth known as *bicuspids* (having two points or cusps) or *premolars* (standing in front of the molars). Next comes the six-year molar already described, then the twelve-year molar and, last of all, the *wisdom tooth*. This large molar appears at any time between the ages of eighteen and forty-five. It frequently fails to appear, and is obviously a tooth which civilized man is losing since his highly refined diet does not require so much grinding as the food taken by his primitive ancestors.

Development of Teeth.—Parents sometimes think that it is a waste of time and money to care for a child's temporary teeth as they are going to be lost later on. Fig. 114 shows that when the temporary teeth are visible in the mouth the permanent teeth are also present in the jaw. Therefore, if the temporary teeth are allowed to decay the disease may spread down to their roots and so to the permanent teeth beneath. Thus the permanent teeth may be diseased even before they appear in the mouth. Because of this it is important to care for a child's temporary teeth.

Use of Teeth.—The chief use of the teeth is to masticate the food. Up and down movements of the jaw enable the incisors to bite off portions of the food while side to side movements enable the molars to grind the food to

pulp. The teeth are also used in speech and loss of teeth may seriously impair articulation. Artificial teeth are rarely as satisfactory as natural teeth for either of these functions, and so great care should be taken to preserve the natural teeth as long as possible.

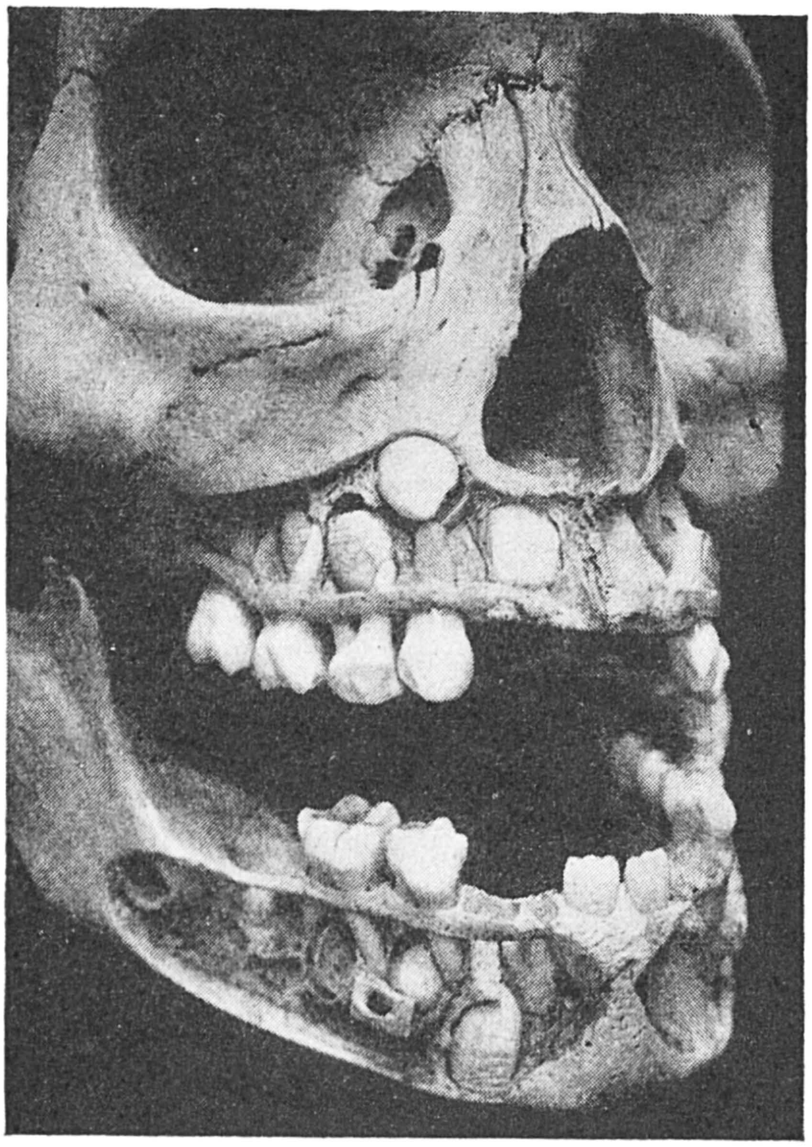


FIG. 114.—The temporary and permanent teeth in the jaw (7 years) (by permission from Humphreys and Wellings, *Dental Anatomy Physiology*).

Hygiene of the Teeth

In order to keep the teeth healthy, attention must be paid to three points. They must be put to proper use, they must be kept clean, and they must receive regular, expert inspection. Each of these points will now be considered in detail.

Proper Use of the Teeth.—Proper use of the teeth means that they must not be used for such purposes as

cracking nuts or breaking cotton. More than this, they must be given the right kind of work to do, as any organ of the body which is not exercised and used tends to waste away. The teeth, therefore, must be made to work and chew hard food. A fault of civilized diet is that much of the food is so refined and prepared that it is too soft to need much chewing. Some coarse and hard food should be included in all diets. A small baby may be given a bone ring on which to exercise his gums when cutting his teeth. An older baby, still living largely upon milk, should have a crust or rusk to gnaw from time to time. Older children and adults should have such hard foods as are shown in Table XVI. The hard food is best taken at the

TABLE XVI.—Foods which Exercise and Clean the Teeth

Hard Fruits and Vegetables.—Apples, raw carrots, lettuce, radishes, some nuts.
Hard Baked Food.—Toast, crusts, rusks.
Fibrous Food (if well chewed).—Oranges, meat.

end of a meal when it not only exercises, but to some extent cleanses, the teeth by scraping off the more clinging, soft foods. Sugary foods, such as those shown in Table XVII, are bad if they are allowed to remain and form a

TABLE XVII.—Soft Foods

Very moist dishes and all "slops."
Cakes.
Jam and preserves.
Chocolate.
Sweets of all kinds.
All food containing sugar.

film over the teeth, as such a film is an excellent breeding ground for the germs that cause decay. Fig. 115 shows that there is a relationship between the amount of sugar in the diet and the presence of dental disease. Children who eat an excess of sweets tend to suffer from decayed teeth, but in a group of children who eat no sweets there is less decay. Of course, some decayed teeth occur even where no sweets are taken, as the figure shows, and this indicates

that sugar alone is not the only cause of the condition. It must be clearly understood, however, that sweets and sugar are good for children in proper amounts, and the teeth only suffer if they are not properly cleaned and freed from the sugary residue.

Food not only affects the teeth from outside, it is also necessary to nourish them from within. The teeth cannot be properly formed unless calcium and phosphorus are present in the diet, and calcium, at least, cannot be utilized to make hard tooth material unless vitamin D is also taken. Such factors as sleep and fresh air may also affect the health of the teeth along with the rest of the body.

Cleaning the Teeth.—The teeth must be kept clean to prevent the accumulation of food residue, and to remove

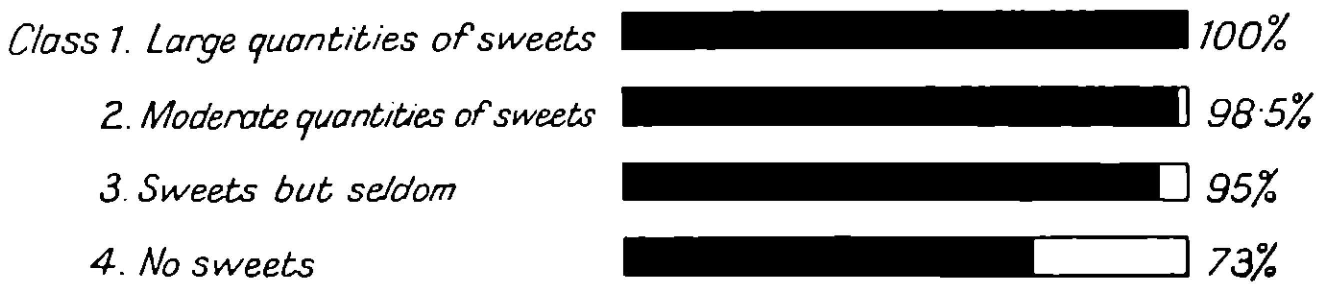


FIG. 115.—Relation between dental decay and sweet-eating. Black shows percentage of children with decayed teeth in each group (after Dr. Sim Wallace).

from them germs such as are always present inside the mouth. Four methods are commonly employed for this purpose.

Tooth-pick method.—A tooth-pick is of some use in removing obvious masses of food from between the teeth, but it is of no use for cleansing the surface of the tooth and freeing it from a thin film of food. The instrument is also liable to scratch the enamel.

Toothbrush method.—The toothbrush is a more effective instrument, and not only cleans the teeth, but also massages the gums in a manner which is beneficial. The brush should not be so hard that it cuts the gums, nor should it be so soft as to be ineffective. A small-headed brush is desirable (particularly for a child's mouth) to enable the more awkward corners at the back to be easily reached.

The toothbrush is commonly used with a side to side movement which does not allow the bristles to penetrate effectively into the spaces between the teeth, where food is most liable to accumulate. A better method is to use the brush with an up and down movement, and best of all is to brush the teeth from the gum towards the free margin, cleaning the backs as well as the fronts of the teeth, and also the biting surfaces of the molars. The value of toothpaste is often overrated and manufacturers make extravagant claims for their products. Most toothpastes are mildly antiseptic but will not in themselves preserve the teeth. The mechanical action of the brush is the most effective agent in keeping the teeth clean and the real function of toothpaste is simply to make the process more pleasant (a point of importance in training children).

If a child cannot be provided with a toothbrush, it should still make some effort to clean its teeth, if only with piece of rag—provided the rag is clean. Instead of toothpaste, a little common salt may be employed, as this is quite an effective antiseptic and also helps to scour the teeth without being too gritty. Children should never be allowed to use such substances as soot or soap upon the teeth. Each of these is commonly employed in some parts of the country and each is liable to do damage.

Floss silk method.—Dental floss silk is a thin, waxed thread, generally sold by chemists wound upon bobbins. A length of the silk, when drawn between the teeth (Fig. 116), effectively cleans the interspaces, which are liable to be missed by the toothbrush. This method, however, can only supplement, and cannot replace, the use of the toothbrush, and the silk may cut the gums if carelessly used.

Soda water spray method.—A very effective method of cleaning the teeth (though rather expensive) is by a fine spray of what is really soda water charged with an antiseptic. The force of the jet cleans the teeth and the spaces between very thoroughly. The spray is charged by small cylinders of carbon dioxide of the "Sparklet" type.

When to clean the teeth.—Theoretically, the teeth cannot be cleaned too frequently and should at least be rinsed with water after each meal. In practice, it is usually only convenient to clean the teeth on rising and retiring. Of the two times, bedtime is much the more important. When the teeth are cleaned on rising they are quickly soiled by the first meal of the day. When they are cleaned at night they remain clean for seven or eight hours and so the time spent upon them is more worth while. There is another reason for cleaning the teeth last thing at night. The saliva is a

FIG. 116.—The use of dental floss silk.

good natural antiseptic which protects the teeth from the germs of decay. Saliva is plentiful in the mouth during the day but is scanty at night (the mouth is usually dryer upon waking than during the day). As this natural protection is lacking during the night, it is important to remove germs from the teeth as far as possible, and also the food residue on which they live.

Regular Expert Inspection.—In spite of care, decay and other diseases may attack the teeth, and treatment will be most effective if the disease is discovered in the early stages, before it is apparent to the individual concerned. It is, therefore, desirable to have the teeth frequently

examined, not by a well-meaning friend or relation, but by a dentist who has the necessary knowledge and facilities for discovering and treating dental complaints. If possible a dentist should see the teeth twice a year. In practice, the School Dental Service is not usually able to achieve this ideal.

Dental Diseases and their Prevention

More than eighty per cent. of elementary school children suffer from dental disease of one sort or another. The effects of these diseases are set out in Table XVIII. A

TABLE XVIII.—The Effects of Dental Disease

1. Pain.
2. Offensive breath.
3. Imperfect mastication of food.
4. Malnutrition from imperfect mastication.
5. Poisoning by pus.
6. Local infection of throat.

tooth may be considerably diseased before any symptoms arise, certainly before pain is felt. Eventually toothache occurs, and this is a very common cause of absence from school and of ill-health from lack of sleep. Offensive breath may be caused by diseased teeth and this has obvious social disadvantages. If many teeth are diseased and painful the child may avoid using them for chewing. This leads to imperfect mastication of the food and so to indigestion. It is possible for malnutrition to arise as a result of imperfect chewing of the food. If pus is formed in connection with the diseased teeth this may be swallowed and so affect the health of the whole body. Poisons derived from the pus may be carried by the blood stream to other parts of the body, causing general ill-health as will be explained later. Infection from a diseased tooth may also spread locally to the tonsils and to the throat.

The two most important dental diseases are caries and pyorrhœa. These will be considered in turn.

Dental Caries.—Dental caries or decay is a condition in which the teeth become soft and crumbling so that cavities form in them. The causes of this complaint may be divided into two groups, as shown in Table XIX. The

TABLE XIX.—CAUSES OF DENTAL CARIES

Imperfect development of the teeth.
1. Lack of hard food.
2. General ill-health.
3. Lack of calcium (lime).
4. Lack of vitamin D.

Imperfect cleaning of teeth.
Food + Germs → Acid (which dissolves the enamel).

teeth themselves may be unnaturally soft and imperfectly developed. This may be due to the fact that they have not

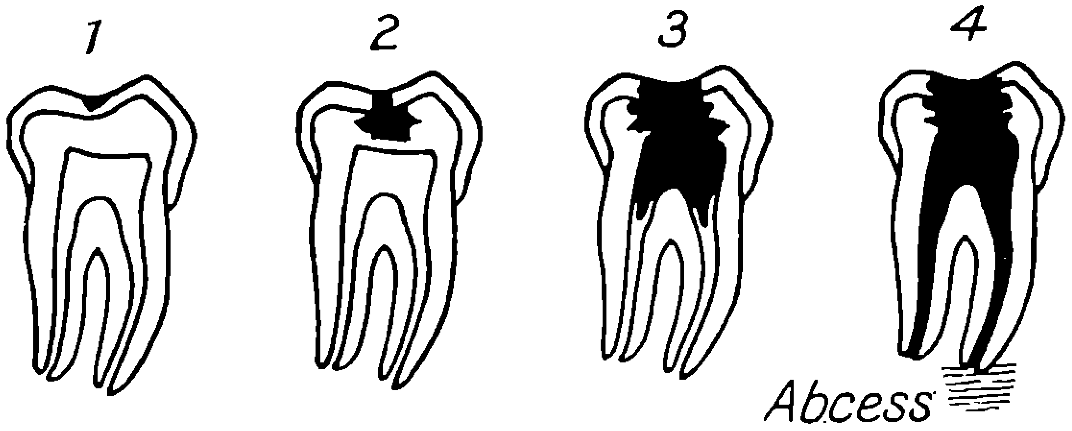


FIG. 117.—The spread of decay. The cement round the roots is not shown in these diagrams.

been exercised by being made to chew hard food. There may have been a period of prolonged ill-health in early life, during which the building of the body was interfered with and the teeth, along with other parts of the body, contain permanent flaws as a result. The diet, too, may be at fault, lacking in calcium or vitamin D, both of which are necessary for the proper formation of hard teeth. Apart from imperfect development the teeth may be neglected. If they are not properly cleaned food accumulates round the teeth, and germs (which are always present in the mouth) act upon this food residue, converting it into acid. The acid dissolves the enamel of the teeth, forming a little hole in which more food can accumulate and so the process goes on.

The spread of decay is shown in Fig. 117. In the earliest

stage only the enamel is involved and the process is generally painless and so escapes notice. Regular inspection of the teeth by a dentist ensures that the disease is recognized at this stage when the treatment is also practically painless. The dentist scrapes out the cavity with his drill and fills up the space with some suitable "filling." If decay is neglected it spreads and involves the dentine. In this case the tooth is generally tender, not aching continually but only during eating or when drinking very hot or very cold liquids. The third stage of decay is where the pulp cavity is affected and, as nerves are present in this situation, severe toothache results. If the disease is allowed to progress still further the pain may get less as the nerve and other contents of the pulp cavity are destroyed. The final result may be the formation of an abscess at the root of the tooth. This is the place where blood vessels enter the tooth from the jaw bone, and an abscess in this situation may easily pass poisons into the blood stream and so cause disease in remote parts of the body. Some kinds of rheumatism can be caused, or at least made worse, in this way. Decay may very largely be prevented by attending to the hygiene of the teeth, keeping them clean, properly exercised and nourished, and by having them examined by a dentist at regular intervals.

Pyorrhœa.—Pyorrhœa is a disease which affects adults more commonly than children, but it occurs in children sufficiently often to merit description here. It is primarily a disease of the gums rather than of the teeth. The gums become soft and flabby and do not afford proper support to the teeth. The causes of pyorrhœa are set out in Table XX. and they fall into two groups. The gums may

TABLE XX.—Causes of Pyorrhœa

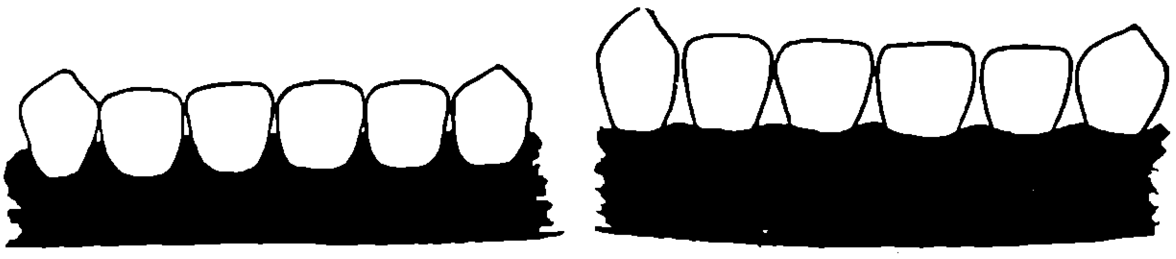
Unhealthy gums.

1. Lack of massage.
2. Lack of vitamins A and C.

Imperfect cleaning.

Accumulation of germs and food residue.

be unhealthy either because they have lacked the stimulating massage afforded by brushing the teeth, or because the diet has been deficient in vitamins A and C. It will be recalled that absence of vitamin A lessens the body's resistance to infection, while absence of vitamin C leads to



Healthy gums. Unhealthy gums.

FIG. 118.—Healthy and unhealthy gums.

softness and unhealthiness of the gums. Although massage is good for the gums, they should not be actually scrubbed with a toothbrush as this tends to make them sore. The incidental rubbing which they receive when the teeth are brushed is quite sufficient. Although the gums may be initially healthy, imperfect cleaning of the teeth may lead to pyorrhoea by allowing germs and food residue to accumulate, thus providing a focus of infection as in the case of dental caries.

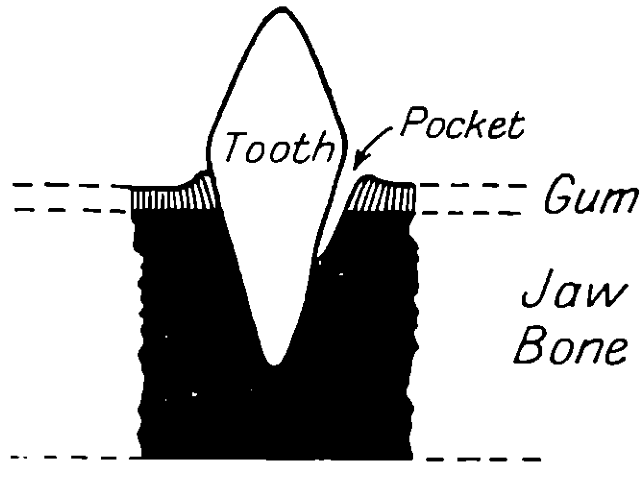


FIG. 119.—Pyorrhœa.

Fig. 118 shows the line of the healthy gum, which practically fills up all the space between each pair of adjacent teeth. The unhealthy gum is also shown, and it will be seen that it has fallen away from the teeth and fails to fill in these spaces. Fig. 119 shows a section of the tooth and gum in pyorrhœa. As the gum no longer clings tightly round the neck of the tooth, a little pocket is formed in which food can collect and undergo decomposition, thus increasing the disease. As a result a tooth may become so loose that it falls out, while pus, escaping from the pocket, is swallowed day by day to the detriment of the general health. If pyorrhœa is detected early enough the dentist

can syringe out the pockets, while subsequent massage restores the tone of the gum. Like decay, pyorrhœa can be largely prevented by attention to the hygiene of the teeth in the ways which have already been explained.

Securing Sound Teeth in School Children.—Dental health may be secured in the school population partly by training in dental hygiene and partly by the provision of an adequate School Dental Service.

Training in dental hygiene.—Older children may be given formal lessons about the teeth, their structure, the reasons for decay and the methods of dental hygiene. Young children are not so likely to benefit from formal instruction and their training should be practical rather than theoretical, leading to the formation of good habits even if the reasons for these habits are not understood. In this case toothbrush drill is useful in school. Ideally the drill would mean that each child had a toothbrush, toothpaste and a mug of water and, with the rest of the class, carried out the movements of brushing the teeth in response to words of command from the teacher, or following the example of the teacher cleaning the teeth before the class. If the necessary apparatus is not available toothbrush drill may be executed with imaginary utensils, the children pretending to clean the teeth and in this way learning the proper procedure to some extent.

School dental service.—At the present time many people will not, and others cannot afford to, take their children regularly to a dentist. For these reasons the School Dental Service has been established to supervise the welfare of children's teeth. The Service is by no means complete throughout the country. Ideally, there would be a twice yearly (or at least yearly) inspection of all children. At present only about half the school population is inspected annually. Of those children who are seen by the dentists, 70 to 80 per cent. are found to be in need of treatment. Of those needing treatment only about 35 per cent. are able to obtain it under the present arrangements.

PART IV

DISEASES OF CHILDREN

CHAPTER 23

CHILDREN'S DISEASES: INTRODUCTORY AND GENERAL

In considering various aspects of physiology and hygiene in previous chapters, certain diseases (of the eye, ear, teeth and nutritional disorders) have been dealt with incidentally. There remain, however, a number of abnormal bodily conditions (a more inclusive term than diseases) which may be conveniently classified as in Table XXI. Each category of this Table will be dealt with in turn in this and succeeding chapters.

Failure of Body Mechanisms

Some diseases arise as a result of a breakdown of one of the natural mechanisms of the body and do not depend upon any injury or infection from outside. The various endocrine disorders which were described in Chapter 10 are examples of this. No more need be said of them here.

Anæmia.—Another example of disease within this category is the complaint, or rather group of complaints, known as anæmia. This means that the blood is not doing its work of carrying oxygen round the body in a satisfactory manner, either because there are not enough red blood corpuscles or because the hæmoglobin, the red colouring matter of the blood, is of poor quality. If the trouble is lack of red corpuscles it may be that not enough are being made or else those made are being destroyed too rapidly.

If the hæmoglobin is at fault the usual cause is lack of iron, as this metal is the important ingredient of hæmoglobin which enables it to act as a carrier of oxygen. In some kinds of anæmia the administration of a medicine containing iron suffices to cure the complaint. In other cases attempts have to be made, by suitable medication,

TABLE XXI.—Abnormal Bodily Conditions

1. *Failure of Body Mechanism.*
2. *Dietetic Deficiency.*
3. *Malformation and Deformity.*
4. *Invasion by Living Organisms* (Parasites).
    Germs: Infectious fevers.
        Chronic germ diseases.
        Minor respiratory diseases.
    Insects:
    Worms:
5. *Functional Disorder.*
6. *Injuries and Emergencies.*
    Injuries: Wounds.
        Burns and scalds.
        Insect stings and bites.
        Fractures.
        Dislocations.
        Sprains.
    Loss of Consciousness: Fainting.
        Epileptic fit.
        Concussion.
        Sunstroke.
        Apparent drowning.
    Poisoning: Corrosive poisons.
        Non-corrosive poisons.
    Foreign bodies in the Ear.
        Nose.
        Eye.
        Throat.

to make good the deficiency of red cells. From the teacher's point of view the symptoms of anæmia are more important than the causes or the treatment. The symptoms are referable to the defective oxygen-carrying power of the blood. Thus the anæmic child suffers from general ill-health and perpetual tiredness, usually appearing pale owing to the poor quality of the blood. He readily gets

out of breath on comparatively slight exertion as his blood cannot cope with the increased demand for oxygen which activity creates. The final diagnosis rests upon a scientific examination of the blood itself and in practice the term anæmia is often loosely applied to any child who is in poor health even though the blood may not be at fault.

Dietetic Deficiency

Ill-health may arise as a result of dietetic deficiency. One of the vitamins may be lacking in the diet, giving rise to such a complaint as scurvy or rickets. There may also be a form of malnutrition such as general undernourishment. Diseases of this type were dealt with in Part II of this book.

Malformation and Deformity

Many of these have also been referred to earlier in the book: flat foot in Chapter 3 and the deformities of rickets in Chapter 16. Some deformities arise as a result of disease of the nervous system. The muscles supplied by the affected nerves can no longer be controlled by the brain and may largely waste away from disuse. The limbs, especially the legs, then take up abnormal positions from lack of the proper influence of the muscles. In some cases the muscles which are cut off from the brain by disease of the nerves pass into a state of chronic contraction or rigidity. This again influences the form and position of the limbs and may give rise to deformity.

Deformities are important in school life because they may interfere with a child's education. They may even prevent his going to an ordinary elementary school unless special means of conveyance are available. Moreover, prolonged treatment may be necessary for the disease causing the deformity and this also interferes with normal education. Special schools are therefore desirable for deformed and crippled children. Day schools are satisfactory in some cases but for progressive diseases necessitating prolonged and elaborate treatment residential

institutions, which are more of hospitals than schools, are preferable. The special education of physically defective children is discussed in a later chapter.

Parasitic Diseases

Still following the list given in Table XXI, we come to the third category, invasion of the body by other living organisms. Such organisms are called *parasites* and the

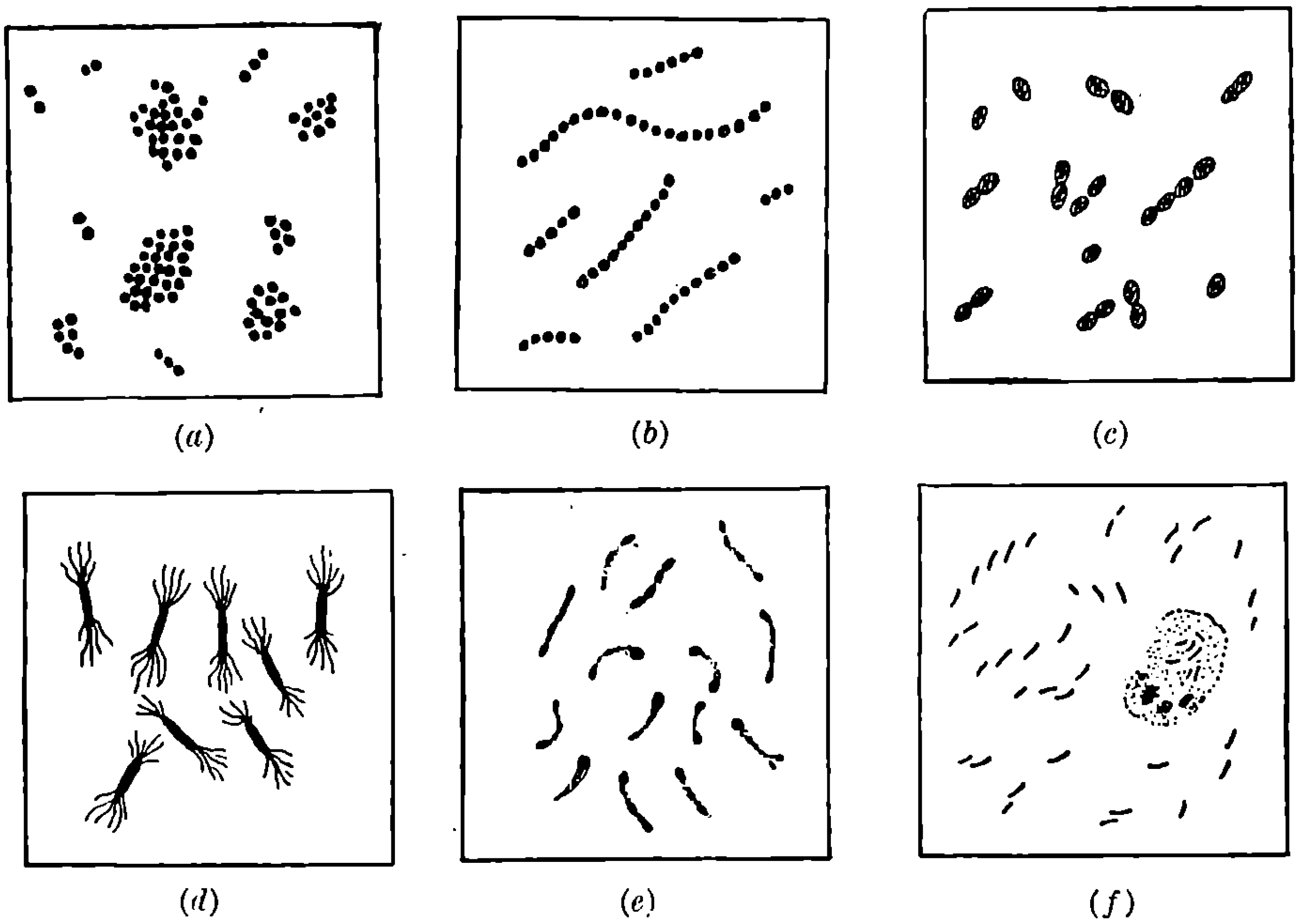


Fig. 120.—Germs.

(*a*) Germs commonly found in boils; (*b*) germs which cause rheumatism; (*c*) pneumonia germs; (*d*) typhoid fever germs; (*e*) diphtheria germs; (*f*) tuberculosis germs.

human being which they invade is termed the *host.* Many kinds of parasite attack mankind in different parts of the world, but those which are at all common in children in England may be divided into three groups: *germs, insects* and *worms.* The germ diseases will be considered first.

Germs.—Germs are minute living creatures, each consisting of a single cell. They are much smaller than the cells in the human body or the amœba, and belong to the vegetable kingdom, being, in fact, minute plants. They

vary considerably in size, but an average size would be $\frac{1}{25000}$ inch. Germs vary also in appearance, as can be seen from the examples given in Fig. 120. Although so minute, they can be seen and recognized by means of the microscope, and a good deal is known about their lives. The terms *bacteria* and *microbes* are also applied to these organisms.

Ultra-Microscopic Viruses.—In addition to the germs which are visible under the microscope, there are others so small as to be practically invisible, even when highly magnified. They are called ultra-microscopic viruses. These viruses are naturally more difficult to study than ordinary germs and less is known about them. Consequently, a disease which is caused by an ultra-microscopic virus is generally more difficult to prevent and to cure than one caused by an ordinary germ. This point will be referred to later.

Germ and Host.—Germs are present everywhere: in the air, on furniture, on clothing, on the surface of the body, and in such apertures of the body as the mouth and the nose. Nevertheless, we do not all suffer from diseases all the time. The great majority of germs are harmless. A certain number are actually beneficial to mankind and are necessary for some agricultural and commercial processes. Some germs, however, are harmful, but even these are not always capable of producing disease. Their power to do so (termed their *virulence*) varies from time to time. This may be compared with the seed of a plant which exhibits the power of growth at a certain season of the year and not at other times. Not only do germs vary in virulence, but their human hosts vary in their power of *resistance* to the germs. Resistance varies in different species of animal, in different races, in different individuals, and in the same individual at different times. The dog, for example, is very resistant to most of the ordinary germ diseases. If it were not so, dogs would quickly die, as they necessarily nose and eat many dirty objects on the ground. English people are fairly resistant, on the whole, to measles, but when this

disease was introduced into a South Sea Island (where measles was previously unknown) hundreds of natives died. The quality of resistance has been compared with the fertility of soil. If seeds are set in a number of gardens in different districts they do not all grow equally well, on account of the varying nature of the different soils. Disease only occurs when germs of high virulence enter a human being of low resistance.

How Germs Produce Disease.—When germs enter the body they give rise to symptoms of ill-health in two ways. In many cases the protoplasm of the germ cells is poisonous to human beings and kills body cells with which it comes in contact. This method of attack is, however, relatively unimportant because it is carried out on a minute scale and is localized to the place where the germs happen to be. Much more important is the germs' power to give rise to chemical poisons which circulate in the blood of the host and so become widespread throughout the body. These germ poisons are called *toxins* to distinguish them from ordinary chemical poisons like prussic acid or arsenic.

The Body's Defences.—The human body has several ways of protecting itself from the attacks of germs. In the first place, phagocytes (the scavenging cells of the blood) accumulate at any place where germs have entered and destroy the invaders by engulfing them. The phagocytes may win this fight, or they may themselves be killed by the germs. This is the type of conflict which takes place in an area of local infection such as a boil, and the resulting pus or " matter " consists for the most part of the dead bodies of germs and phagocytes—the casualties from the battle. Phagocytic defence is not successful against all kinds of germs, as many of them multiply very rapidly. They multiply, like the amœba, by dividing in two, and this may take place as often as once every twenty minutes. One germ may thus give rise to a considerable number in the course of a few hours and, as the original invaders are like to number hundreds of thousands in the first instance, it is easy to see that they quickly get beyond restraint from

the phagocytes. Other, and more effective, defences then come into play.

Many of the cells of the body can produce antidotes to neutralize the toxins of the germs. Such antidotes are called *antitoxins.* It is not sufficient, however, for the toxins to be neutralized if the germs are left alive to continue producing more poisons. Therefore, the body cells also produce chemical substances which are poisonous to the germs. These are called *antibacterial substances.* Thus the germs are trying to poison the host by toxins and the host is neutralizing the toxins by antitoxins and poisoning the germs by antibacterial substances. Antitoxins and antibacterial substances are sometimes spoken of together as *antibodies.* We may say, therefore, that the body's defences are the phagocytes and antibodies.

Spread of Germ Diseases.—Germs may spread from one individual to another in a number of ways. Four of these ways are common and important, and will now be described.

Spread through air.—Where the germs are present in the respiratory passages of the host (the common cold, influenza, consumption) they may be breathed or coughed into the air and so reach other people. People who suffer from these and similar complaints should take care not to cough in an unguarded manner, particularly in confined spaces like rooms, tramcars, and railway carriages. This mode of spread is called *droplet infection,* as the germs are contained in drops of saliva which are breathed or coughed out.

Spread through contact.—Close contact with an infected person also permits the transference of germs. This applies not only to contact with the individual himself, but also to contact with things which he has used or handled, such as clothing, bedding, towels, table utensils and books. In some diseases the patient's excretions are also infective and precautions have to be taken to protect those who are nursing him.

Spread through animals.—Animals may spread infection in three ways. A domestic dog or cat which is allowed to run in and out of a sick room may carry germs just like the inanimate objects mentioned in the last paragraph. Domestic and farmyard animals also suffer from some of the same diseases as man, and in such a case the sick animal must be regarded as an infectious person. Milk is a source of infection sometimes, as germs flourish in it readily. If a cow suffers from tuberculosis the germs of this disease may be present in the milk. Even a disease like diphtheria (from which the cow does not itself suffer) may be spread by milk, from an infected dairy-worker to the consumer. The means adopted for securing a pure milk supply have been described in Chapter 14.

Spread through water supply.—The water supply of most parts of England is carefully controlled and kept pure. In some country districts, however, it has happened that germs of disease have got into the drinking water and so have reached a large number of people. Badly constructed cesspools are particularly liable to leak and contaminate nearby wells, or water may be drawn from a stream to which sewage has access higher up. Animals, too, may foul surface waters which are used for human consumption.

Groups of Germ Diseases. Diseases which are caused by germs may be classified in many different ways. For our purpose in considering diseases of children it is convenient to divide them into three groups (Table XXI): acute infectious fevers, chronic germ diseases and minor respiratory diseases. In the next chapter we shall be concerned with the first of these groups.

CHAPTER 24

INFECTIOUS FEVERS

THE diseases which fall into this group have the characteristics implied in the term *Acute Infectious Fevers.* They are generally acute, that is sudden and dramatic in their onset and course. They are infectious and may spread through a community as an epidemic. They are all accompanied by a feverish condition (high temperature, etc.) and so are termed fevers. Examples of these diseases are diphtheria, scarlet fever, measles, whooping cough and smallpox—diseases which are usually treated in a special fever hospital.

General Characteristics of Fevers.—The symptoms of the various fevers differ from one another in detail but

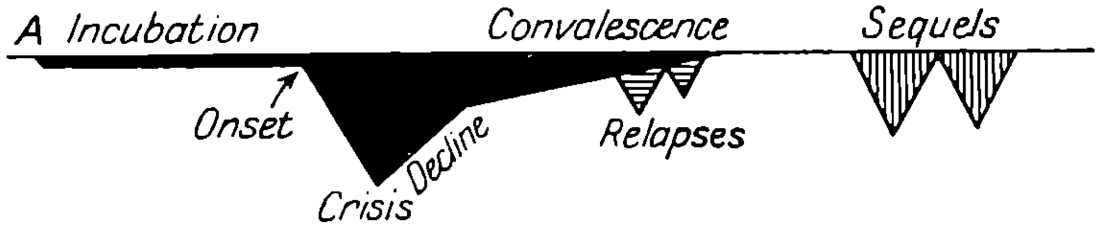


FIG. 121.—The course of infectious fever.

all of them have certain characteristics in common. Fig. 121 is a graph representing the course of one of these diseases. The base line represents normal health and the further the curve falls below the base line the greater is the deviation from normal health.

Incubation period.—The point A is where germs of disease enter the body and, since this must be regarded as an abnormal condition, the graph begins to fall below the

base line. Nevertheless, there are no actual symptoms of ill-health at this stage: there is nothing to indicate that the individual has become infected. The germs are concerned with establishing themselves in the body and multiplying and have not yet begun to cause any ill-effects. This phase of the disease is called the incubation period. The incubation period varies in different diseases but is fairly constant for any one disease. Thus it is generally from two to five days in the case of diphtheria, about seven days in whooping cough, and fourteen days in measles. In many fevers the patient is infectious during the incubation period and can transmit the disease to other people although he does not yet appear to be ill.

Onset.—After the incubation period there comes a time when obvious signs of illness make their appearance. This is known as the onset and occurs because the germs have now established themselves within the body and are producing their toxins in considerable quantities. The change from the symptomless incubation period to the obvious presence of disease is often very abrupt. At the onset the patient feels ill and the temperature rises. Headache is usual, children frequently vomit and infants may have convulsions. In many of the fevers a characteristic rash makes its appearance some time after the onset.

Crisis.—The symptoms very rapidly get worse and a child who was well one day may be very ill indeed the next. Overwhelmed by toxin, the patient is at this stage losing the battle. The point of maximum intensity of the illness is called the crisis. Here one of two things may occur. Either the patient loses the fight completely and dies, or else his body begins to manufacture antibodies in sufficient quantity to defeat the germs.

Decline.—If the crisis is satisfactorily turned the patient's antibody production causes a disappearance of the symptoms produced by the germs' toxins. This phase is known as the decline and it, again, is often very rapid.

Convalescence.—The patient does not return to perfect health with the decline of the symptoms. The body has been so exhausted by the conflict with the germs that a variable period of convalescence is necessary for complete restoration to health. A patient often remains infectious to others during the early part of convalescence. In most cases this phase completes the course of the disease and normal health is resumed, as shown in the figure by the return of the graph to the base line. In some cases, however, certain other events take place.

Relapses.—The decline of the disease may not be a regular rise of the graph to its base line. Irregular returns of the symptoms may occur which are termed relapses. It is as if the germs, although defeated in the main battle, continue to fight a rearguard action. A relapse, of course, is a return of the original symptoms : it is not a new disease.

Sequels.—Sometimes, after normal health has been completely restored, certain diseases may make their appearance as a result of the fever. For example, scarlet fever may so affect the kidneys that certain kinds of kidney disease tend to arise. These after-effects are called sequels and are new diseases, not returns of the fever itself, though they would not have occurred without the fever as a preliminary.

The mere fact that the patient negotiates the crisis successfully indicates that he has in his blood antibodies to protect him against the particular germs which have caused his illness. Moreover, his body has learnt to produce these antibodies very readily. If germs of the same type enter the body later in life the appropriate antibodies are either still present in the blood or are very rapidly produced. The germs are, therefore, not allowed to incubate and cause disease. Consequently, it is very uncommon for a person to have a second attack of any of the infectious fevers.

Treatment of Infectious Fevers.—The treatment of infectious fevers is carried out from two points of view : that of the community and that of the individual.

Disease.	*Nature and Early Symptoms.*	*Mode of Infection.*	*Usual Age of Onset.*
Measles.	Running eyes and nose like a cold followed by a rash of deep red spots.	Breath. Discharge from nose. Close contact.	About 5 yrs.
German Measles.	Rash of rose-pink spots. Other symptoms rare.	Close contact.	All ages.
Diphtheria.	Sore throat, swollen glands of neck, may be discharge from nose.	Breath. Discharge from nose. Sputum. Close contact.	1-5 years.
Smallpox.	Headache, sickness, backache and shivering. Raised spots or blebs on face, wrists and trunk. Later, scabs in same places.	Close contact.	All ages.
Chickenpox.	Blebs and, later, scabs, somewhat like smallpox, but little general illness.	Close contact.	Under 10 yrs.
Scarlet Fever.	Headache, sickness, sore throat. Red flush of skin and, later, scaling of skin. May be ear or nose discharge.	Breath. Saliva. Peeling skin. Close contact.	About 5 yrs.
Whooping Cough.	Begins like a cold but violent cough develops, accompanied by whooping sound and causing vomiting.	Breath. Sputum. Close contact.	Under 6 yrs.
Mumps.	Swollen and painful glands at angle of jaw.	Breath. Close contact.	5-15 yrs.
Enteric Fever.	General illness. Severe diarrhœa.	Close contact. By excreta.	10-30 yrs.
Cerebrospinal Fever.	General illness and vomiting, Occasionally purple-red spots on the skin.	Breath. Close contact.	Under 5 yrs.
Infantile Paralysis.	General illness and sudden paralysis, often of a leg.	Close contact.	Under 5 yrs.
Sleepy Sickness.	Very varied but increasing lethargy usual.	Close contact.	Any age.

Incubation Period.	*Quarantine for Contacts.*	*Isolation for Patients.*	*Notes.*
7-14 days.	3 weeks.	3 weeks from appearance of rash.	Use of convalescent serum affords protection.
14-21 days.	3 weeks.	2 weeks from appearance of rash.	A distinct disease from measles but sometimes confused with it.
2-10 days.	Until shown free from infection by bacteriological examination.	Until shown free from infection by bacteriological examination.	Shick Test, Antitoxin, Immunization } See text.
10-14 days.	3 weeks unless recently vaccinated.	Until all scabs have gone from skin.	Vaccination affords complete protection for some years. Should be repeated in later life.
10-21 days.	3 weeks.	Until all scabs have gone from skin.	May be confused with smallpox but is not so serious. Vaccination does *not* prevent chickenpox.
1-8 days.	1 week.	Until free from discharges and peeling on uncovered parts of body.	Dick Test: see text.
6-18 days.	6 weeks.	6 weeks or until cough has gone.	Note the unusually long quarantine period for contacts. This is usual where infants are concerned.
12-24 days.	3 weeks.	1 week after all swelling subsides.	It is the salivary glands which are swollen.
10-15 days but very variable.	Not usual.	Until shown free from infection by bacteriological examination.	The term " enteric " includes typhoid and paratyphoid fevers which have similar symptoms.
1-5 days.	1 week.	Until shown free from infection by bacteriological examination.	Also known as spotted fever or cerebrospinal meningitis.
Uncertain.	Not usual.	Prolonged treatment necessary.	Also known as acute Poliomyelitis.
Uncertain.	Not usual.	Prolonged treatment necessary.	*Not* connected with the tropical sleeping sickness. Also known as Encephalitis Lethargica.

Protection of the community.—In order to prevent an epidemic, patients are isolated from the rest of the community while infectious, that is until sometime during convalescence. The exact period of isolation varies in different fevers and has been decided, in each case, as a result of experience. Anyone who has been in contact with a patient may have caught the disease and be in the incubation period. Therefore, " contacts " should also be isolated for the usual duration of the incubation period of the disease in question to see whether or not the disease makes its appearance. This isolation of contacts is termed *quarantine*.

Isolation can be most effectively carried out in a special fever hospital where there is an experienced staff and proper facilities for disinfection. To be efficient, isolation must include not only the patient himself but utensils, bedding, clothing and all other things that he uses. Only after proper disinfection should these articles be admitted amongst healthy people.

Treatment of the individual.—Treatment of the individual is directed towards assisting his body to fight the invading germs. Very little can be done to help phagocytic defence, but much can be done in other ways. Anti-toxin can be produced artificially as in the case of diphtheria. A small dose of diphtheria toxin is injected into a large animal such as the horse. The horse then produces antitoxin and so does not suffer any ill-effects. Over a period of weeks the dose is increased until the animal is very resistant indeed owing to the large quantity of antitoxin which is present in its blood. Some of the blood is now drawn off and the antitoxin is separated from it. If a human being is suffering from diphtheria and is nearing the crisis, some of this artificially produced antitoxin may be given to him to tide him over until his own body produces antitoxin to combat the disease. The administration of antitoxin in this manner has completely changed the outlook in diseases such as diphtheria. Antitoxin is also useful during the incubation period. If a person has been in contact with a

case of disease and is, presumably, incubating it himself, administration of antitoxin will prevent the disease from developing because, as soon as the germs produce their toxin the necessary antidote is already available.

Sometimes it is desired to protect a person against a disease to which he has not yet been exposed if it is fairly certain that he will be exposed to it at a future date. In this case it is no use giving antitoxin as it would disappear from the blood in the course of a few weeks thus leaving the individual defenceless. Artificial antitoxin (unlike that produced by the body itself) only affords temporary protection. One way of making a person safe from an infectious disease is to give him an attack of that disease, then, if he recovers, he will never have a second attack. This is obviously not a practicable procedure but the same result may be obtained by giving a dose of dead germs or toxin which has been rendered inactive by suitable means. Although in this case there is only a sort of " sham fight " instead of a real battle, the body learns to protect itself in exactly the same way as if there had been an actual attack of the disease. Antibodies are produced and remain in the blood for a long time and, what is more important, the body has acquired the function of producing these antibodies at short notice if required on future occasions.

The process of protecting by the injection of inactivated toxin is generally called *immunization*, the material used being termed a *serum*. Protection against future contagion by the use of dead germs is called *vaccination* and the mixture containing the germs, a *vaccine*.

Carriers of Infectious Disease.—Some individuals in the community may harbour germs of infectious diseases and transmit them to other people without themselves suffering from the disease. They are known as carriers and may be divided into three groups. Obviously, a person who is incubating a disease is a carrier of sorts as also is a person who is recovering from a disease but who is still infectious. The most important group, however, is

formed by those who are called healthy carriers: people who are naturally immune to a certain disease but who, nevertheless, harbour the living germs of that disease. Such people often constitute a problem during an epidemic, as there are not the same legal means of restricting their activities as there are in the case of those who have actually got an infectious fever.

Common Infectious Diseases

Some of the individual fevers will now be discussed in detail, partly because of their importance and partly to illustrate some further general principles.

Measles.—Measles is a disease which is caused by an ultra-microscopic virus. It spreads from one person to another by contact either with a patient or with infected articles which he has handled or worn, or by droplet infection. It is most common in early childhood. Older members of the population have either had the disease and so become immune to further attacks, or else they have acquired immunity from having repeated small doses of the virus as they went through life: a sort of natural vaccination. This is true of most fevers.

Course and symptoms.—The incubation period is seven to fourteen days, and the first symptoms are those of an ordinary cold in the head: the patient feels ill, the temperature is raised and there is coughing, sneezing and watering of the eyes. On the fourth day after the onset the characteristic rash of the disease makes its appearance (Fig. 122). The rash is first seen on the head round the margin of the hair: behind the ears and on the forehead and temples. The rash spreads down the trunk and limbs, the older spots fading as the disease progresses. Individual spots last about twenty-four hours and the whole process of spread occupies about six days. The spots are somewhat crescent-shaped in the early stages, they are of a dusky red colour and they have a velvety feeling. Measles is not in itself a dangerous disease, but the sequels

to which it gives rise are often serious and not infrequently fatal. As the disease begins like a cold in the head it is not surprising that the sequels are also diseases of the respiratory system: bronchitis and pneumonia. The middle ear is sometimes infected and, even if a child escapes all sequels, a general debilitated condition is usual

FIG. 122.—Measles (by permission from Goodall and Washbourne, *Infectious Diseases*. Lewis).

after measles. One attack usually protects for the rest of life.

Exclusion from school.—Measles is very infectious during the incubation period, before any symptoms have made their appearance. For this reason it is difficult to prevent the spread of the disease. Those who are known to have been in contact with a case should be excluded from school for three weeks. This more than covers the usual

incubation period and, if no symptoms appear during this period, it may be assumed that the contact has not caught the complaint. The patients themselves should not be allowed to return to school until three weeks has elapsed since the rash disappeared. During an epidemic of measles it is obviously wise to regard with suspicion any child who has a bad cold.

Treatment.—In the case of a virus disease it is not ordinarily possible to produce an artificial antitoxin, as the virus cannot be isolated and cultivated like an ordinary germ. Recently, however, a method of preventing and treating these diseases has been originated and is employed in measles. This is the method of using *convalescent serum.* If a person has had measles, particularly if he is only just convalescent, his blood must contain antibodies to this disease as otherwise he would not have recovered. These antibodies can be extracted from the blood (constituting the convalescent serum) and, if given to a patient, will cut short an attack of measles or, administered during the incubation period, will prevent the development of the disease. Convalescent serum is being increasingly used in a number of diseases which are caused by ultra-microscopic viruses.

German Measles.—This disease, although often confused with measles, is a distinct entity and the name is entirely misleading. It is a much milder disease than measles and generally gives rise to no symptoms other than the presence of a rash. In this case the rash appears on all parts of the body at once and there are no preliminary signs of a bad cold. The incubation period is longer than that of measles, being from fourteen to twenty-one days. Although German measles is not a serious complaint it is not pleasant to have a rash running through the school as an epidemic. Therefore, those who have had the disease are excluded from school until they are no longer infectious: usually a week after the rash has disappeared. Contacts should be excluded for three weeks after exposure to possible infection.

Diphtheria.—Diphtheria is caused by an ordinary, recognizable germ and has been the subject of much study. As in the case of measles, the disease is most common in early childhood, adults being relatively immune. The germs may be spread in a number of ways: by direct contact, droplet infection, infected articles and carriers. Milk may also convey diphtheria germs, although the cow does not suffer from this complaint. If, however, germs get into the milk from a human source they live and multiply and in this way reach the consumer.

Course and symptoms.—The incubation period varies from two to ten days, but is commonly about three. The onset is often insidious, and does not suggest a serious disease. The child feels somewhat off colour and may have a sore throat, though not severely so. The diphtheria germs do not spread all over the body, but remain localized in the throat. Here they give rise to the formation of a characteristic greyish-white membrane—a thin "skin" which covers the throat and tonsils. The lymphatic glands of the neck become enlarged, but there is no rash in this disease. Sometimes diphtheria affects the larynx, and the membrane may then seriously interfere with breathing. Infection of the nose may also occur and, during an epidemic of the disease, inflamed, discharging nostrils should always be regarded with suspicion. The toxin of the diphtheria germ circulates in the blood of the patient and is particularly poisonous to muscles. It is not uncommon, therefore, to have paralyses of various kinds occurring as sequels, the muscles of the eyes, soft palate, heart or limbs being affected. If the heart is involved death may occur through heart failure, and this can happen during the disease itself or sometime after apparent recovery.

Exclusion from school.—Children who have had diphtheria should not be re-admitted to school until the nose and throat are free from the germs. These regions should be swabbed with sterile cotton wool and the swabs submitted to bacteriological examination. This method of ascertaining definitely whether or not the child is free from

infection is only practicable in a disease like diphtheria, where the germs are confined to one (accessible) part of the body. Contacts should be similarly examined before being allowed to return to school.

Treatment.—The preparation of artificial antitoxin and its use in the treatment of diphtheria has been described earlier in this chapter. Reference was also made to the production of permanent immunity by the administration of inactivated toxin.

The Schick test.—This is a test (named after the originator) which may be performed upon a group of children in order to ascertain which members of the group are susceptible to diphtheria, so that they may be immunized in anticipation of a future epidemic. A minute quantity of diphtheria toxin is injected into (not under) the skin of the forearm. If a child is immune to diphtheria and already has antitoxin in his body, the toxin is neutralized and nothing occurs. If he is not immune and has no antitoxin in his body, a small area of redness occurs at the site of injection. This constitutes a positive result, and indicates that the subject of the test is likely to catch diphtheria if exposed to it and should therefore be inoculated. The test is quite painless, the toxin is only introduced into the skin (whence it cannot spread) and, as no actual germs are used, no harm can occur. In some people the mere pricking of the skin and introduction of an organic fluid causes a certain amount of reddening. To differentiate between a reaction of this type and a real positive result, it is usual to perform a control test on the other arm. For the control a small quantity of heated (and therefore inactivated) toxin is used. This may give rise to some reddening of the skin, but a positive result on the test arm will show a much more marked reaction.

Smallpox.—Smallpox is a very infectious disease which was exceedingly common in olden days. Indeed, the population in times past represented simply the survivors of smallpox epidemics. The rash of smallpox is important, as it causes permanent scarring which is very disfiguring on

the face. Modern methods of prevention have made this disease much less common and less dangerous.

Vaccination.—The most important factor in preventing smallpox is vaccination, a process introduced by Jenner at the end of the eighteenth century. Jenner observed that dairymaids rarely suffered from smallpox, although they were frequently attacked by cowpox, a somewhat similar, though milder, disease. It appeared that cowpox was a modified form of smallpox, and those who had had the disease in the mild form were rendered immune to the more serious form. The original method of vaccination was to inoculate people with cowpox, the necessary material being derived from human patients. This sometimes led to the transference of other diseases from which these people might be suffering and, as antiseptic methods were not employed, ill-effects often arose. For these reasons the practice of vaccination met with some opposition. Nowadays, vaccine lymph is obtained from specially selected calves and great care is taken to ensure a high standard of purity. The law allows parents to avoid having their children vaccinated if they "conscientiously believe that vaccination would be prejudicial to the health of the child." As the parents are unlikely to understand the rationale of vaccination or its effect upon health, it is improbable that their opinions have any value. The protection afforded by this process is well illustrated in Fig. 123.

Chicken-pox.—This complaint is characterized by a rash which somewhat resembles that of smallpox. The two diseases are not, however, related in any way, and chicken-pox is rarely dangerous. The name leads to the same sort of confusion as exists in the case of measles and German measles.

Scarlet Fever.—Scarlet fever is characterized by soreness of the throat and a red flush upon the skin. It is not nowadays a very serious complaint in itself, but it gives rise to important sequels. Infection of the middle ear, inflammation of the kidneys, and valvular disease of the heart may all follow scarlet fever.

The Dick test.—This test is carried out in exactly the same way as the Schick test for diphtheria. In this case scarlet fever toxin is employed and the Dick Test indicates susceptibility to this disease. The name is that of the inventer of the test.

Other Infectious Fevers.—Some other infectious fevers occur fairly commonly in children, but they have no

Fig. 123.—Smallpox. (The patient's vaccinated baby has escaped the disease) (by permission from Gamlin's *Modern School Hygiene*. Nisbet).

outstanding point which requires special mention. Table XXII gives such information as a teacher may require about all the usual infectious diseases.

School Closure.—At one time it was usual to close a school, when an epidemic appeared amongst the children, in an endeavour to prevent the spread of the disease. In the case of a rural school this may be satisfactory, as the

children generally live at farms and in small villages scattered over a wide area of countryside. School closure thus diminishes the possibility of contact between infected and non-infected children. In a town, however, the children usually live close to one another in the neighbourhood of the school. If the school is closed they play together in the streets and in their homes, and so are in more intimate contact than if they continued attending school under a certain amount of discipline and supervision. Complete school closure is not practised very much nowadays, more reliance being placed upon the exclusion of patients and contacts, with the occasional closure of a single department.

Control of Infection.—From what has been said about the nature of fevers, the methods of controlling infection will be apparent. They may be briefly summarized here. Those actually suffering from an infectious disease should be isolated from the rest of the community, and isolation should extend also to all things used or handled by patients. Those who have been in contact with infection should be isolated until the lapse of the incubation period, when it will be seen whether or not they actually develop symptoms of the disease. In those fevers for which artificial antitoxin can be prepared, it should be used whenever the disease is suspected. Tests such as the Schick and Dick tests should be employed whenever possible to ascertain susceptible children, and they should be immunized by some suitable process of inoculation or vaccination. Finally, attention to the general hygiene and health of the community tends to diminish the ravages of all diseases.

Points of Importance in an Infectious Fever

It is not desirable for a teacher to attempt to learn all the details about every infectious disease, but during an epidemic certain points should be looked up and borne in mind.

Chief symptoms.—The early symptoms of a disease which is prevalent should be known, so that the teacher

can keep a watch for the signs of a cold, the presence of a sore throat or whatever it may be that indicates the onset of the disease in question.

Mode of infection.—A knowledge of the mode of infection is important, so that the teacher may know whether one child is likely to infect the whole class very readily or whether the disease will only spread amongst his intimate associates.

Age of onset.—The teacher should know the age of child most likely to be attacked, although, during an epidemic, personal suceptibility is a more important factor than age.

Incubation period.—A knowledge of this affords an indication of when to be specially vigilant for further outbreaks after a patient has been discovered in the school. It should be borne in mind that many of these diseases are very infectious during the period of incubation, before actual symptoms have appeared.

Quarantine and exclusion.—Patients should be excluded from school until they are no longer infectious. The necessary period has been decided by experience in most cases. In some diseases, such as diphtheria, it is possible to make a bacteriological examination to decide definitely whether or not there is any possibility of further infection. In any case, a patient should not be considered free from infection if any abnormal discharge (as of the nose, eye or ear) persists. Contacts should be isolated for rather longer than the incubation period of the disease which they are thought to have contracted.

CHAPTER 25

TUBERCULOSIS AND RHEUMATISM

REFER again to Table XXI. After infectious fevers comes a group of germ diseases which may be called chronic because, generally, they take a long time to develop and, having made their appearance, take a long time to cure. They are not nearly so infectious as the acute infectious fevers. The two most important diseases (from the point of view of school hygiene) which may be placed in this group are tuberculosis and rheumatism. Each of these will be described in turn.

TUBERCULOSIS

Tuberculosis is a complaint which may attack any part of the body. Sometimes general symptoms of ill-health predominate ; at other times the symptoms are localized or confined to one part of the body. The disease is caused by a germ known as the *tubercle bacillus*. The abbreviation T.B. is commonly used in referring to this germ, and also in referring to the disease itself. The tubercle bacillus is shown in Fig. 120. Different varieties of it commonly attack different species of animal. There is the so-called human type, and also the bovine type which affects cattle. Both of these may attack human beings who can thus catch the disease from the milk of infected cows.

Special names are given to the disease when it attacks certain regions of the body. Tuberculosis of the lungs is called phthisis or consumption ; of the joints, hip disease, knee disease or whatever joint happens to be affected. Tuberculous meningitis is the term used when the meninges or coverings of the brain are involved, while the more rare

tuberculosis of the skin is called lupus. The reader who comes across any of these terms applied to school children should remember that they all stand for the same disease, tuberculosis.

Spread of Tuberculous Infection.—What has been said of the spread of germ diseases in general is true of tuberculosis, but two ways in which this complaint spreads are of particular importance.

Spread by air.—If a person has tuberculosis of the lungs or any part of the air passages the germs may be breathed or coughed into the air. If the infected person spits, the germs may get into the air when the sputum dries up. In these ways the germs reach other people. The infection is not, however, readily caught. Casual contact with the germs is not so dangerous as with the germs of the infectious fevers, and so we do not have epidemics of tuberculosis. Long-continued exposure leads to infection, and this occurs in such circumstances as when two brothers share the same bedroom, particularly if they share the same bed. The disease thus tends to spread in families.

Tuberculosis is not inherited from birth, but a congenital weakness or predisposition to the disease is inherited. The child of tuberculous parents is very likely to catch this complaint and, being exposed to infection in his own home, he generally does catch it. It is this circumstance which gives rise to the erroneous belief that the disease is inherited.

Spread by milk.—It has already been pointed out that cattle may suffer from tuberculosis and the milk may be infected. In this way human beings may get the disease, and this applies particularly to children who form the principal part of the milk-drinking population. Contracted in this way the germs are particularly liable to infect the bowels, the lymphatic glands and the joints. Tuberculosis in these regions of the body is therefore common in children.

Nature and Characteristics of Tuberculosis.—Where the disease occurs the germs poison the body cells so that

they die and become soft, presently forming a mass of material of cheese-like consistency in which the germs are embedded. This naturally interferes with the function of the organ involved and gives rise to symptoms of illness.

Tuberculosis of the lungs.—When these softened areas occur in the lungs there is a persistent, chronic cough. If a small blood vessel has been involved in the tuberculous destruction some blood may be coughed up from time to time. The sputum contains the germs of the disease and so spitting, always a dirty habit, in this case becomes a dangerous habit. For some reason which is not understood sufferers from tuberculosis of the lungs often sweat excessively at night-time and have a high temperature. The reader who fancies that he or she sweats somewhat to excess should not immediately conceive the idea that tuberculosis is present, as many other symptoms are necessary to establish a diagnosis.

Tuberculosis of joints.—When a joint is affected by tuberculosis it becomes swollen, tender to touch and painful when moved. The muscles surrounding the joint enter into a state of more or less permanent contraction in order to prevent the painful movement. Later, the joint may become so completely disorganized by the disease that the nerve-endings are destroyed and pain is no longer felt. At this stage it may be possible to move the joint freely, even in abnormal directions.

Tuberculosis of lymphatic glands.—In lymphatic glands tuberculosis causes swelling, tenderness and, if the gland is near the skin (as in the neck), a discharge on to the surface of the body.

General symptoms.—Although the local symptoms vary according to the part of the body attacked, as has just been explained, tuberculosis almost invariably produces certain general symptoms which are the same in all cases. These are a feeling of ill-health, loss of appetite and, usually, considerable loss of weight. Such symptoms occurring in any child would naturally suggest the presence of some disease.

If any of the foregoing local symptoms were present too, tuberculosis might be suspected and the child referred to the school doctor.

Prevention and Cure of Tuberculosis. — As tuberculosis is encouraged and spread by overcrowding, undernourishment, lack of fresh air and sunshine, spitting and contaminated milk, rectification of these things tends to prevent the disease. Education in hygiene would lead people to remedy these unhygienic conditions as far as possible. Those who have actually got tuberculosis, and whose homes do not permit satisfactory treatment, should spend some time in a sanatorium where they can live under very good hygienic conditions. In most diseases it is not desirable to talk to the patient about his complaint, but tuberculosis is an exception. Sanatorium authorities teach their patients a certain amount about tuberculosis, so that they may know how to care for themselves when they leave the institution and so that they may know also in what ways they constitute a danger to their families. Children who have to spend a considerable time in such an institution may be given such schooling as their condition permits, to prevent a complete interruption of their education.

Rheumatism

Rheumatism is a somewhat vague and loosely used term which includes a number of abnormal conditions. Many painful diseases of the joints in old people are called rheumatism of one sort or another. We are not concerned with these here. Rheumatism of children is quite different and is a definite disease caused by a germ (Fig. 120). In many cases the disease develops slowly and necessitates prolonged treatment for its cure. For these reasons it may be placed under the heading of chronic germ diseases. Although a germ disease, rheumatism is not infectious even in the limited manner of tuberculosis. The disease may be made manifest in children in a number of different ways which will be briefly described.

Types of Rheumatics.—***Rheumatic fever*** is the most acute form of rheumatism and somewhat resembles an infectious fever in its onset. It may come on very suddenly, with a high temperature, sore throat and swelling and pain in all the joints of the body. There may be profuse sweating, and sometimes there is a rash upon the skin. With such severe symptoms a child is naturally kept at home and so does not come within the teacher's notice. The sore throat and joint affection should be kept in mind, however, and compared with what occurs in some other forms of rheumatism (which are seen in school) as described below.

Growing pains.—Some children suffer from time to time from vague pains in the limbs, particularly in the legs. These are often lightly dismissed by parents as "growing pains." Normal growth, however, is a painless process and the so-called growing pains are really mild manifestations of rheumatism. The joint pains, in fact, without the other signs characteristic of rheumatic fever.

Rheumatic sore throat.—Everyone is likely to suffer from a sore throat on occasion, but when a child has repeated attacks of sore throat and tonsilitis it is often a manifestation of rheumatism. This time the throat symptoms without joint pains.

St. Vitus' dance. Another manifestation of rheumatism is St. Vitus' dance or *chorea* (Greek, khoreia, dancing). This is rheumatism of the brain. The complaint is characterized by marked fidgetiness and irregular twitching of limbs, face or head. The child also lacks concentration, his attention jumping from one subject to another. The twitching movements often cause the patient to drop objects which he handles, such as a cup at the table or a pen in school. This, combined with fidgeting, usually draws attention to the disease.

Rheumatic heart disease.—Any of the forms of rheumatism just described may lead to rheumatic heart disease. Growing pains and rheumatic sore throat rarely do so,

however. Rheumatic fever commonly does so. Rheumatic heart disease may also arise by itself without any other manifestation of rheumatism as a preliminary. It should be clearly understood that all kinds of heart disease which affect children are not of rheumatic origin. When rheumatism affects the heart, the germs settle in the valves which separate the auricles from the ventricles (Chapter 5). The valves become inflamed, hard and distorted, so that they no longer function properly. When closed they do not fit accurately together, resembling a pair of folding doors which have warped badly. In consequence of this, blood is able to leak back in the wrong direction through the heart. The hardening of the valves does not permit their proper opening either, and so the blood is obstructed even when flowing in the right direction. As a result of these defects, the heart has to do extra work in order to maintain the efficiency of the circulation. The heart, therefore, undergoes development (like any other muscle) and becomes larger, and so may compensate for the defect quite successfully. In some cases the heart becomes overstrained and unable to compensate adequately unless the individual leads a very quiet life without much exertion (which would put extra demands upon the heart). The importance of rheumatic heart disease lies in these cases where it produces permanent incapacity to lead a normal active life.

Treatment of Rheumatism. In all the serious forms of rheumatism treatment is directed towards saving the heart and preventing permanent invalidism. This necessitates absolute rest in bed for weeks, or even months. When a child gets about again, he may not be fit to attend an ordinary elementary school and should go to a special school, such as one for the physically defective (Chapter 32). In some districts there are special institutions for these children, called by some such title as The Home of Recovery for Cardiac and Rheumatic Children. Such an institution is primarily a hospital and only secondarily a school. When first admitted, the children remain in bed all day.

In this condition a certain amount of oral teaching is possible, and reading may be arranged in one of two ways. The more expensive is by the use of special spectacles which enable a child, while lying down, to read a book which rests upon his chest—seeing round the corner, as it were. The second method is to have a plate glass table over the bed (above the child's face) upon which a book may be placed face downward so that he can read it. As

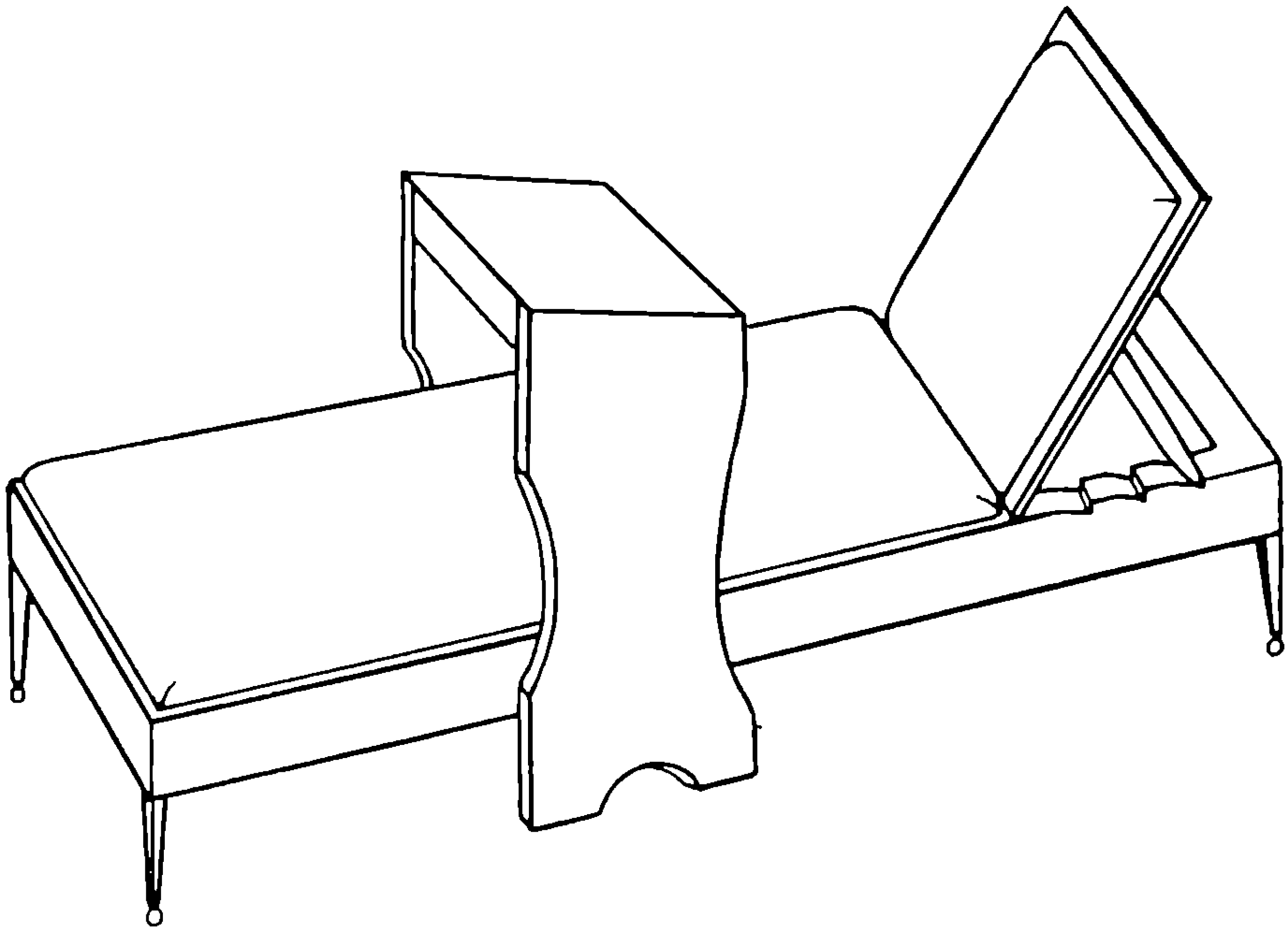


FIG. 124.—Reclining couch for rheumatic children with adjustable desk.

the children progress, they get up for a gradually increasing time each day, when they may attend (for not more than four hours in any one day) at an attached schoolroom. Here they occupy reclining couches (Fig. 124) so that they can lie down for many of their lessons, sitting up only for short periods to do such work as must of necessity be performed at a desk. There is no competitive element or pressure in the teaching and the children are not allowed to exert themselves unduly. Carefully controlled physical exercise may also be introduced in the later stages where

the heart condition permits. If a child is likely to be permanently affected by rheumatism, it is desirable to give him vocational training, that is to say, he should be taught an occupation by means of which he can earn his living in later life. Thus, having learned a suitable trade, he will be less likely to drift into an occupation for which the condition of his heart completely unfits him.

CHAPTER 26

SKIN DISEASES

THE common diseases of the skin which attack children are caused by germs or insects. Therefore, in this Chapter, we have to deal with parasites which come under two of the sub-headings of the fourth category of Table XXI. We are not concerned with skin diseases which affect only one individual but with those which can spread from one child to another. Those skin diseases which can spread may be termed contagious rather than infectious as the parasites (whether germs or insects) can only be transmitted by contact with the infected skin and are not as readily transmissible as the germs which cause the infectious fevers.

Impetigo.—This disease is popularly known as "scald head." It is frequently caused by germs which normally inhabit the skin surface. If the individual is in poor general health, particularly if the skin is dirty and frequently scratched, these germs may get into the skin and so cause the disease. The commonest site for impetigo is the face where it occurs round the edges of the apertures : the mouth, the nostrils and the eyes (Fig. 125). First of all, small blisters appear which presently dry up and form hard crusts of a characteristic yellow colour. The places itch exceedingly. The disease may spread to other children by contact with the patient, his clothing, or towels which he has used.

Treatment.—As impetigo is contagious, children should be excluded from school while suffering from the disease. The treatment is, first of all, to remove the crusts by starch poultices or warm olive oil. The raw surfaces which are thus exposed should then be treated with some suitable

lotion or ointment. The most commonly used remedy is white precipitate ointment, containing mercury which kills the germs. Measures should also be taken to improve the general health.

Ringworm.—This disease is caused by a minute fungus, but for practical purposes it may be looked upon as a germ disease for the distinction is only of academic interest. It

FIG. 125.—Impetigo (by permission from Garrod Batten and Thursfield, *Diseases of Children*).

is important to realize that the name is misleading, as ringworm is not in any sense caused by a worm. The fungus spreads from one individual to another by personal contact, or by contact with the clothing or other objects. Two kinds of ringworm are commonly distinguished : ringworm of the body and ringworm of the scalp.

Ringworm of the body.—Ringworm of the body may occur on the trunk, the limbs or the face. It begins as a

red patch which does not usually itch (Fig. 126). The area of redness spreads out in circular form while the centre of the patch loses the red colour and becomes normal. This produces a characteristic ring which gives the (misleading) name to the disease. Ringworm of the body is generally easily cured by the application of antiseptics such as

FIG. 126.—Ringworm (by permission from Macleod's *Diseases of the Skin*. Lewis).

white precipitate ointment or ordinary tincture of iodine. Whether or not an infected child should be allowed to attend school depends chiefly upon the situation of the ringworm and the possibility of other children's coming in contact with it.

Ringworm of the scalp.—When the scalp is attacked the appearance is somewhat different from that just described.

More or less bald patches appear which are covered with scurf or scales (Fig. 127). From amongst the scales protrude stumps of hairs which have broken off short. The hairs break in this way because the parasite extends down to the root and interferes with the nutrition of the hair. For this reason the application of antiseptics to the surface does not usually effect a cure, and the modern treatment is

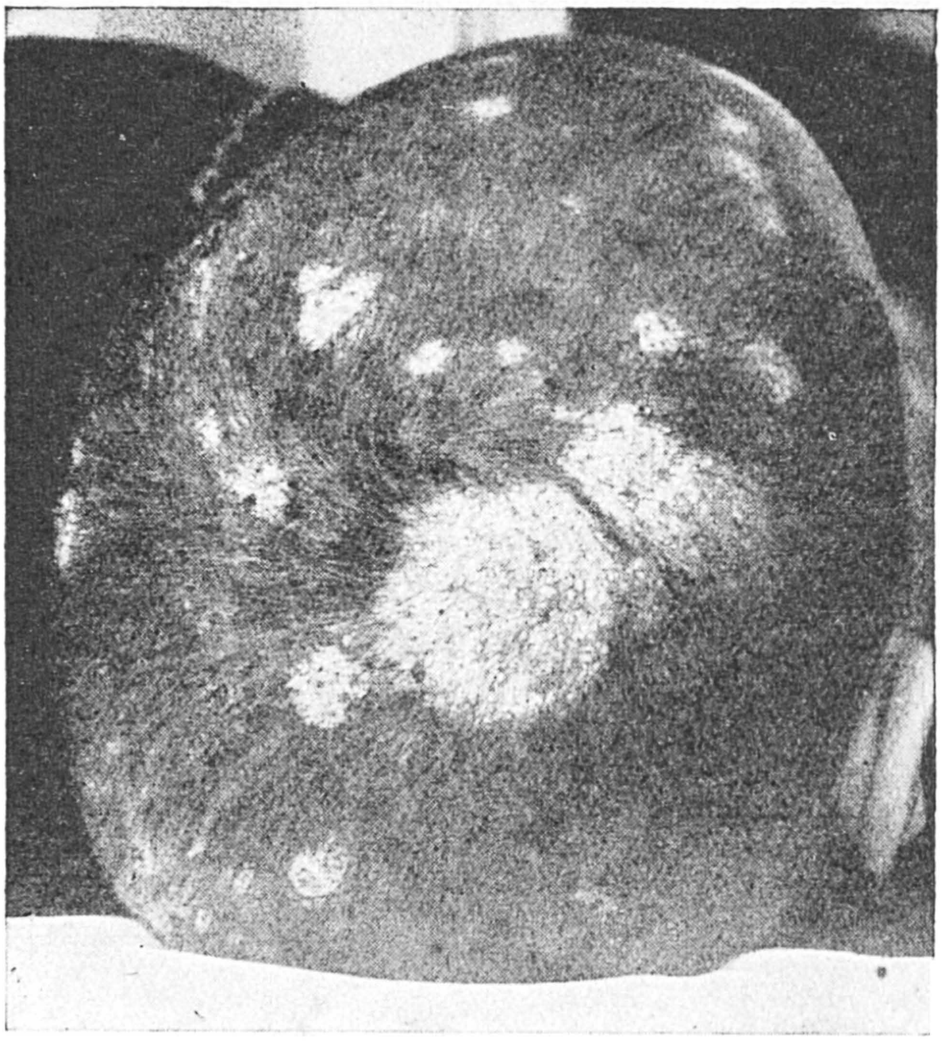


FIG. 127.—Ringworm of the scalp (by permission from Garrod Batten and Thursfield, *Diseases of Children*).

by means of X-rays. Children should be excluded from school until the disease is cured.

Scabies.—This disease, popularly known as "itch," is caused by a small insect which is just visible to the naked eye. Fig. 128 shows its appearance when highly magnified. The female insect burrows in the skin in order to lay her eggs. She chooses those parts of the body where the skin is thrown into folds such as the webs of the fingers, the skin wrinkles in front of the wrists formed when the hand

is bent forward, the arm-pits and so on. The places itch intensely, particularly when the patient becomes warm in bed. Scratching follows and this may lead to secondary infection of the skin by germs ; blisters and scabs resulting. The insects readily travel to other people and the complaint rapidly spreads through a family. Contagion is very easily effected where two people share a bed. Scabies may be suspected or recognized by the intense itching it produces, by the site affected and, sometimes, by the recognition of the burrows as minute black lines in the skin.

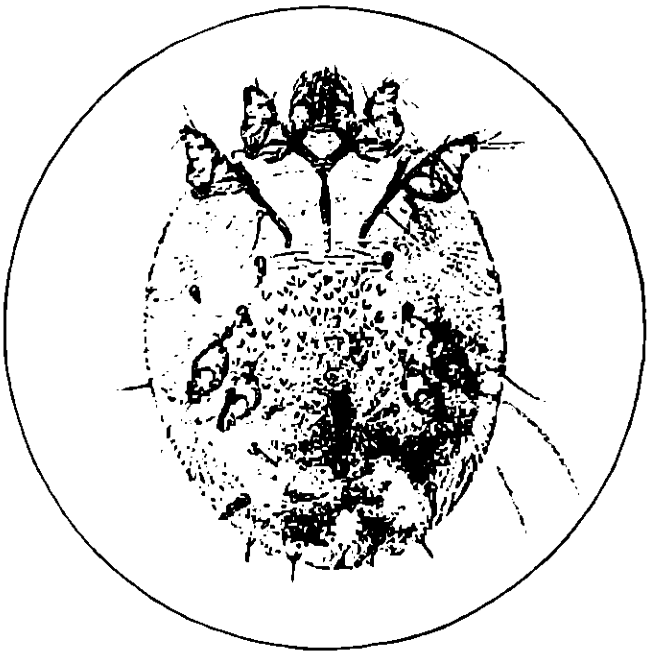


FIG. 128.—The itch insect (from Savill's *Clinical Medicine*).

Treatment.—The child should be excluded from school and treatment applied on three successive nights. This consists in taking a hot bath and scrubbing the skin vigorously with a nailbrush. The burrows are thus opened up and the body is then anointed with sulphur ointment, which kills the insects. The child must be put to bed in some old night attire.

Pediculosis.—Pediculosis is the condition of being infested with *pediculi* (singular, pediculus) or *lice*. Lice may infest either the head or the body, but for our purpose here head lice are the more important. The louse lives amongst the hairs and sucks blood from the scalp and this causes considerable irritation. The female louse lays eggs which

are called *nits*. They are attached to the hairs by a sticky mixture which the louse produces. The nits are oval in shape and are fixed to the hairs at one end, the free end pointing away from the scalp in the same direction as the free end of the hair (Fig. 129). The lice readily pass from one person to another, particularly if hats are indiscriminately exchanged and worn.

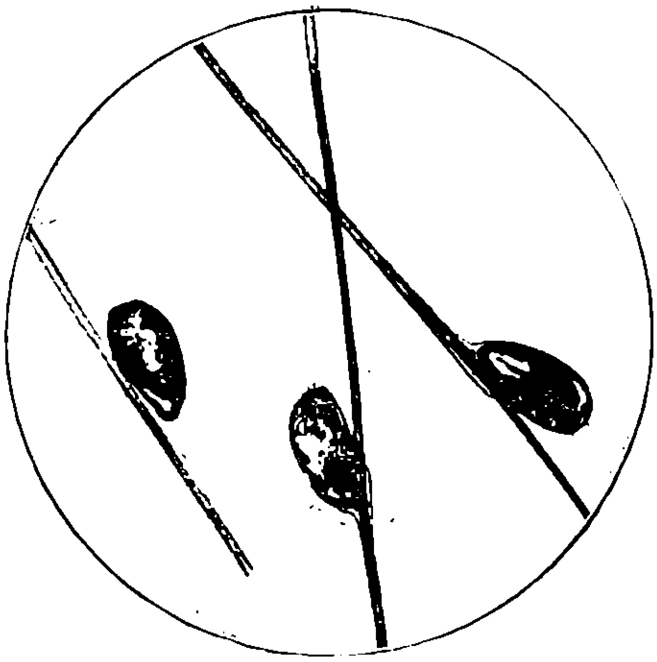


FIG. 129.—Nits attached to hairs (from Savill's *Clinical Medicine*).

Treatment.—While alive, the louse clings tightly on to the hairs by means of its specially adapted feet (Fig. 130). In order to remove lice they must therefore be killed. This may be done by bathing

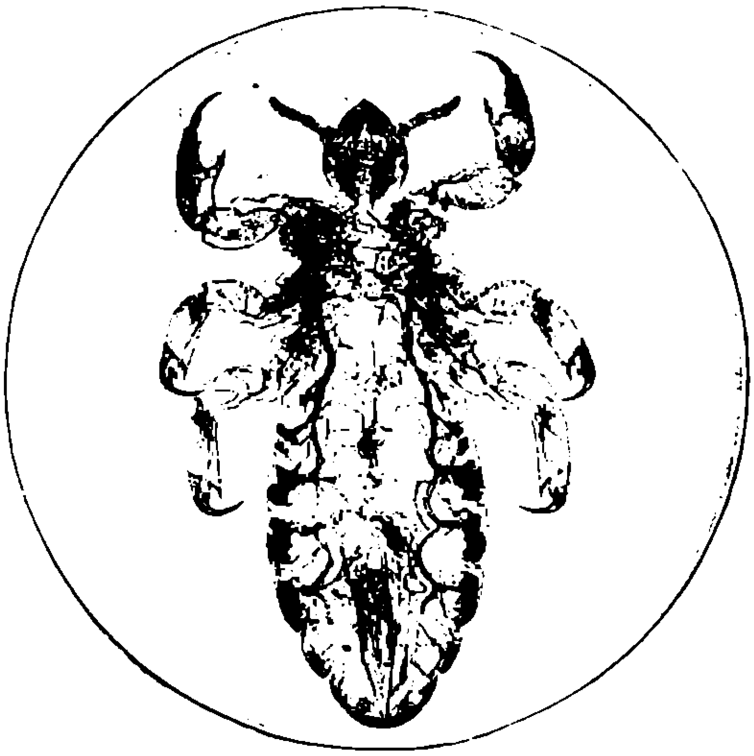


FIG. 130.—The head louse (highly magnified) (from Savill's *Clinical Medicine*).

the hair with an antiseptic substance (such as carbolic acid) or with an oily liquid (such as paraffin). After this the hair should be bound up in a covering for some hours.

If an antiseptic has been used the lice are poisoned, and if oil has been used they are suffocated as the oil prevents their breathing. In either case they leave go of the hair and may be combed out. On account of the manner in which the nits are attached, a comb tends to glide over them without pulling them off the hairs. Therefore, the adhesive substance, by means of which they are attached, should first be softened. This can be done by bathing the hair in vinegar and then the nits may be combed out. Fine steel combs are now available by means of which the head may be freed from lice and nits without any preliminary applications. Body lice live in the clothing next to the skin and so may be got rid of by treating this clothing in a steam sterilizer.

Legislation.—If a child is in a verminous condition, the parents may be given notice to cleanse him within twenty-four hours. If they do not comply with this notice, the Local Education Authority may cleanse him, and if the parents again permit the child to become verminous they may be prosecuted. Another method of dealing with such a case is to exclude the child from school, and then to prosecute the parents for not putting him in a fit condition to attend.

CHAPTER 27

OTHER PARASITIC DISEASES

In following Table XXI in the last four chapters, one category of germ diseases has not yet received attention, nor have complaints caused by worms been dealt with. These are the subjects of the present chapter. Minor respiratory diseases will be described first, and this title includes the common cold, influenza, adenoids and enlarged tonsils.

Common Cold and Influenza.—Real influenza is a specific disease which occurs in epidemics and is very often fatal. As ordinarily used, however, the term means little more than a very bad cold, and so these two complaints may be discussed together. The symptoms of a cold are familiar to every one and need not be described here. The complaint is caused by germs which are normally present in the upper respiratory passages (the nose and throat) without ordinarily producing symptoms of ill-health. When the bodily resistance is low for any reason (as after exposure to damp and cold) these germs are able to make an attack and produce disease. There is some evidence that an ultra-microscopic virus is the actual causal factor which prepares the way for the attack of the germs. No specific treatment is known for a cold, and the best thing to do is to help Nature to overcome it by remaining in bed with consequent warmth and rest. The majority of people have not got the right attitude towards the common cold, and look to doctors (and to quacks) to produce some magic cure. The only real hope of controlling this complaint is for people in general to realize that the common

cold is an infectious disease, and that isolation of sufferers is desirable. The cold in itself is not important, but, if neglected, it may lead to major respiratory diseases such as bronchitis and pneumonia.

Adenoids and Enlarged Tonsils.—Reference has been made (in Chapter 6) to the tonsils and adenoids, and their position and significance have been explained. When adenoids occur, they are generally accompanied by enlarged tonsils, but the most important symptoms are caused by the adenoids. The resulting blocking of the nose causes the mouth to be kept open. This increases the liability to respiratory infection, because the air is not so well filtered or warmed by the mouth as it is by the nose. The adenoid child has a characteristic vacant expression (Fig. 29) and is often backward in school on account of deafness. The deafness is due to the fact that the adenoids obstruct the lower end of the Eustachian tube and, as air is prevented from reaching the middle ear, the hearing is impaired, as explained in Chapter 21. When adenoids have been surgically removed, the child may need to be taught to breathe properly as mouth breathing, though no longer necessary, persists as a habit.

Worms.—A considerable variety of worms attack mankind in different parts of the world, and most regions of the body are liable to infestation by these parasites. The parasitic worms which are at all common in England infest the alimentary canal, chiefly of children. These worms are acquired from eating imperfectly cooked meat which may itself contain the eggs of the worms. They also gain access to the body if children habitually put in their mouths fingers with which they have played in dirt. The symptoms of worm infestation are frequently vague and elusive. Nutrition tends to be impaired, the child being always hungry, as the worms are living upon the food which is intended to nourish the child. The action of the bowels is disordered, diarrhœa commonly occurring, but sometimes constipation. General signs of irritability are also

found, such as grinding of the teeth and biting the finger nails. Both of these symptoms may, however, occur from other causes. The treatment of worm infestation is beyond the province of the teacher, and the complaint is not important from the point of view of school hygiene, except in as far as it interferes with nutrition or distracts the child's attention from his lessons.

CHAPTER 28

HYSTERIA, EPILEPSY AND STAMMERING

The fifth category of abnormal bodily conditions listed in Table XXI is that termed functional disorders. These disorders are complaints in which there is no demonstrable abnormality in the structure of the body, but its function, or the behaviour of the individual, is abnormal. The three commonest functional disorders in school-life are hysteria, epilepsy and stammering.

Hysteria

Hysteria is a condition in which certain symptoms make their appearance without any physical change being detectable. Symptoms of almost any disease may be present. Sometimes paralysis of a limb, suggestive of disease of nerves or muscles, may be seen. If it is established that the nerves and muscles are healthy, and no explanation of the paralysis can be found, then the disease is properly labelled functional or hysterical. In children, hysteria often takes the form of uncontrolled emotional outbursts or apparent fainting. Hysterical fainting differs from ordinary fainting in several particulars. The face is generally well coloured in contrast to the pallor of an ordinary faint. The pulse also remains regular and strong, whereas in ordinary fainting it is irregular and weak. The hysterical child generally falls on to a chair or form, or in some other convenient situation, usually in circumstances calculated to attract attention. Most important of all, consciousness is not lost during hysterical fainting, as it is in ordinary fainting.

It might appear from what has been said that hysteria is just another name for naughtiness, but this is not the

case. Naughtiness implies conscious, deliberate misconduct. The hysterical symptoms, however, are produced by the unconscious rather than by the conscious mind, and the patient is not entirely responsible for them. It may be that a child does not receive the attention (at home or at school) which it feels to be its due. It may be that it does not get on well with a certain teacher, or during a certain lesson. In either case, the unconscious mind seeks a solution to the problem by producing symptoms of ill-health. This makes the child the centre of attention, or allows it to escape from the unpleasant situation.

Treatment.—Punishment is obviously useless and cruel in a case of true hysteria, but it is important to realize when children are merely naughty, and not to let them escape proper punishment by loosely calling them hysterical. A certain amount of firmness is, however, proper in the treatment of those cases where hysteria is used as a means for securing notice. In more involved cases psychological investigation and advice are necessary. If there is any doubt as to whether a given case is one of hysteria or not, it is as well for the teacher to regard it seriously until expert advice has been obtained, otherwise more important diseases may be overlooked from time to time.

Epilepsy

Epilepsy is a disorder of the nervous system characterized by attacks of unconsciousness (deep unconsciousness in this case) with or without convulsions. When the unconsciousness is accompanied by convulsions, the terms *major epilepsy* or *grand mal* are used. When unconsciousness occurs without convulsions, the terms *minor epilepsy* or *petit mal* are used. The disorder is hereditary and runs in families.

Major Epilepsy.—An attack of major epilepsy may be preceded by some giddiness and pallor. Often, however, these preliminary symptoms are absent. The patient suddenly falls unconscious, sometimes crying out as he falls. So sudden is the attack that the epileptic has no

time to choose his place of falling and often hurts himself severely. After lying where he fell for perhaps half a minute, all the muscles in the body contract, so that the patient becomes completely rigid. After a further half minute, or thereabouts, convulsions begin. The limbs are moved wildly and the body is jerked about, the teeth are chattered together and there is frothing at the mouth. This phase again lasts about half a minute, when the convulsions cease, the body becomes relaxed, and the patient lies quietly unconscious. Recovery occurs in about half an hour, but the individual, although again conscious, may not be perfectly normal or fully aware of what he is doing.

There is no way of cutting short an attack of epilepsy. All that can be done is to prevent the patient from injuring himself during the convulsions. With this object in view, a child should be brought out from amongst the desks (before the convulsions begin) to an area of open floor, preferably out of sight of other children. The tongue is likely to be bitten when the teeth are chattered together, and the corner of a thickly folded cloth should be placed between the teeth to prevent this. It is sometimes recommended that a cork should be used. Not only is it unlikely that a cork will be readily available when required but, if it were used, it would almost certainly be swallowed, with undesirable results. The bladder shares in the convulsions of the rest of the body and urine is commonly expelled during an epileptic fit. This should always be reported when medical advice is sought for a child who has fits, as it is absolutely characteristic of this complaint and aids the doctor considerably in an otherwise difficult diagnosis.

Minor Epilepsy.—In minor epilepsy there are no convulsions, but simply attacks of unconsciousness. These may be of very short duration and easily escape notice for a long time. The patient may be talking and merely pauses as though he had lost the thread of his discourse, and then continues what he was saying without being aware that anything has happened. In some circumstances the momentary unconsciousness may lead to serious results,

such as falling off a bicycle. At the very least, the epileptic may drop and break articles which he is handling. After an attack of minor epilepsy, a patient may be in one of two states. He may be perfectly normal and resume his previous occupation. On the other hand, he may be in an abnormal mental state in which he is not fully aware of what he is doing and so is not responsible for his actions. What are known as "automatic actions" are performed in this state. These actions may be quite harmless, as when a man overwinds and breaks his watch each time he has a fit. On the other hand, automatic actions may be such as to bring a child into conflict with his teachers, or an adult into conflict with the police. Minor epileptics have been known to walk into a shop, pick up some object, and walk out with it without being aware of what they were doing. Cases have also occurred where the irresponsible patient began to undress in a public place, and occasionally unprovoked attacks have been made on other people by epileptic subjects.

Treatment of Epilepsy.—Those who are subject to very frequent attacks of epilepsy should attend special schools, or should inhabit epileptic colonies. In these places drugs may be administered and diet and mode of life so ordered as to depress the excitability of the nervous system to some extent, and thus diminish the liability to fits. If epileptics pass out into the ordinary world, they should be discouraged from taking up unsuitable occupations (involving climbing ladders, controlling machinery, etc.), in which they may be a danger to themselves or to others. They are now prevented by law from driving motor cars. Epileptics should not have children, as the complaint is hereditary, and feeblemindedness tends to run in the same families.

Stammering

Stammering or stuttering is a functional disorder which occurs in nervous and self-conscious children. It is not due to any defect in the physical apparatus of speech but to lack of co-ordination and muscular control. Usually, too,

the child is over-anxious about speech and devotes too much conscious attention to the mere act of speaking. About 1 per cent. of children stammer, and boys are more commonly affected than girls in the proportion of three to one. Two types of stammering may be differentiated. One is where the defect is present from the time the child first begins to speak. The other is where stammering develops after speech has been normal for some time. The second type is generally easier to cure than the first.

Treatment of Stammering.—Adenoids, unhealthy tonsils, and any other physical abnormality should first of all receive attention if they are present. Then, provided the child has reached the age of about nine years, he should be placed in a special class of ten or a dozen children under a specially trained teacher. With older children it is desirable to have separate classes for the two sexes, as they are likely to be less self-conscious in the exclusive presence of their own sex. In some parts of the country the stammering child attends the special class continuously for a period. In other districts attendance is part time, the rest of the time being spent in the child's ordinary school.

Several systems of training are in vogue. Most of them involve breathing exercises, exercises for the tongue and lips, and the careful study of lip positions, often with the aid of a mirror. Singing and intoning are used as the children rarely stammer when producing the voice for these purposes. In some areas no ordinary speech at all is attempted for the early weeks of the period of training. It is very desirable to have the co-operation of the parents, who should see that the child performs recommended exercises at home, and who should also understand the necessity for refraining from ridiculing his attempts at speech. Under some systems of training it is claimed that 78 per cent. of cases are improved, including 45 per cent. who become perfect speakers.

CHAPTER 29

ACCIDENTS AND EMERGENCIES

THE last category of abnormal bodily conditions listed in Table XXI is the group of injuries and emergencies which may require first-aid treatment. Those which commonly occur among children may be classified (as the Table shows) under four headings: injuries of various degrees of severity, loss of consciousness from various causes, poisoning, and the entrance of foreign bodies into the apertures of the head, the eye, the ear, the nose and the throat.

INJURIES

Wounds.—Wounds vary in severity from a mere abrasion of the skin or a small cut to large gashes. In all cases first aid treatment should have two objects: checking bleeding and preventing infection. In the case of a small scrape or cut the application of a simple disinfectant, like tincture of iodine, will usually kill any germs which have entered the wound. Bandaging or the application of a plaster will shut out other germs which may attempt to enter afterwards. The bandage or plaster should be firmly applied in order to exert pressure upon the wound, as this checks bleeding. Although a certain amount of pressure is thus desirable, a bandage should not be so tight as to interfere with the circulation, say of a limb, and cause the fingers or toes to turn black.

In the case of a severe wound, such as a deep gash in the forearm, infection cannot be prevented, as germs will have been carried into the depths of the wound by the instrument which produced it. Disinfection in such a case necessitates special knowledge and special materials. A wound of this

magnitude bleeds freely and the loss of blood may be serious unless it is checked early. With all severe wounds, therefore, first aid treatment is directed primarily to checking the bleeding. Fig. 131 represents two blood vessels of the arm. The artery brings blood from the heart in the chest while the vein conveys used blood back to the heart. The arrows in the figure show the direction in which the blood is flowing in each of these vessels. If a deep injury involves the artery, the emerging blood has certain characteristics by which it may be recognized. Being pure blood, it is bright red in colour. Owing to the direction of the flow, the blood comes from the side of the wound nearer to the heart. As the force of the heart is immediately behind the blood in the artery, it emerges in a series of spurts synchronous with the heart's action. To check bleeding of this type a bandage should be bound round the limb between the wound and the heart. Through the bandage should be thrust a piece of stick or other rigid object and then, by rotating the stick, the bandage may be drawn so tight that it exerts pressure upon the whole limb, compressing the artery inside and thus stopping the bleeding. A bandage of this kind is called a *tourniquet* and is illustrated in Fig. 132.

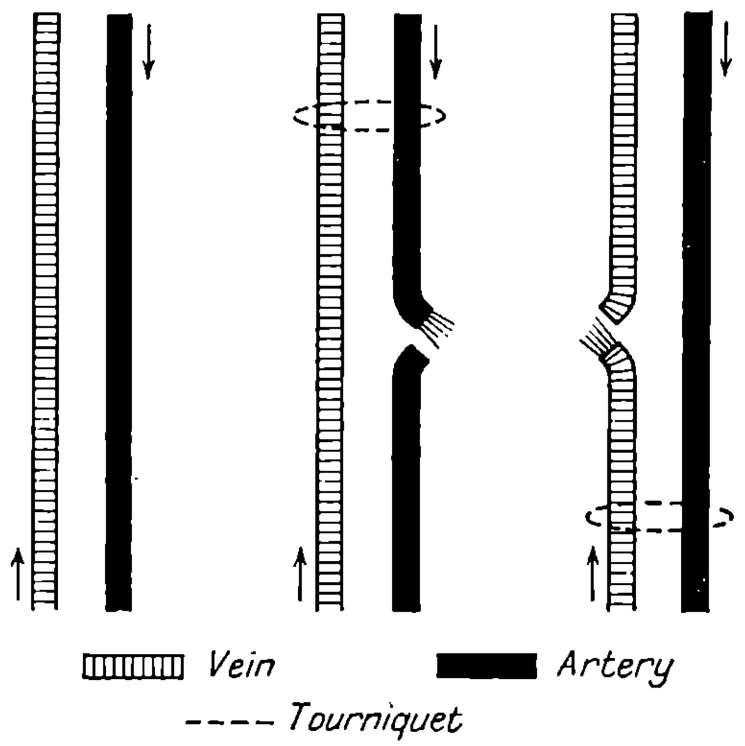


FIG. 131.—Injuries of blood-vessels.

If a vein is divided in a wound (Fig. 131) the bleeding has other characteristics. The blood, being impure, is of a somewhat dark red colour. Owing to the direction of the flow, it comes from the side of the wound further from the heart. As the heart's action is not immediately behind the blood in a vein, it flows in a steady trickle, not in spurts. To check bleeding of this type a tourniquet should be applied

as before but, in this case, on the side of the wound further from the heart. In practice, it is usually very difficult to decide which type of bleeding is occurring in a deep wound, and valuable time would be lost in trying to settle this point. It is therefore advisable to apply tourniquets on each side of all wounds. After checking the bleeding a clean bandage should be arranged to cover the injury and a surgeon's attention should be sought.

Shock.—Any severe injury, especially if much blood has been lost, is liable to be accompanied by a condition known

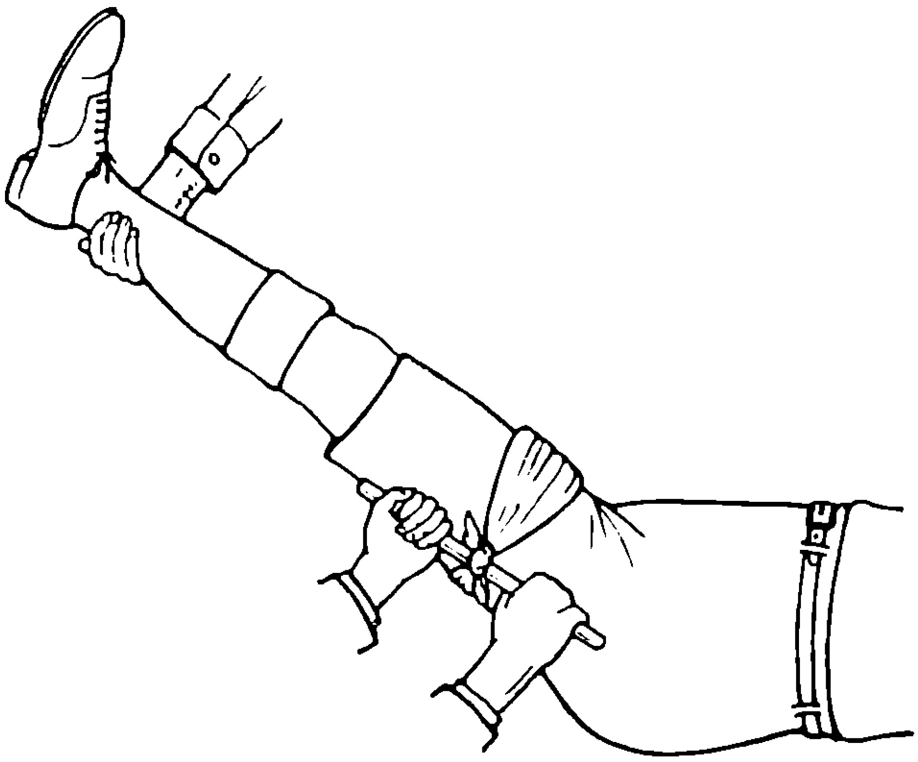


FIG. 132.—A tourniquet.

as shock. In this state the patient feels faint and may lose consciousness, he shivers and feels cold and his blood pressure falls. After dealing with the injury itself, and while waiting for skilled medical attention, it is important to treat shock. This should be done by keeping the patient warm with blankets, rugs, coats, hot water bottles or whatever means may be available. If unconscious, the patient should be laid flat on the ground (see fainting), but, if conscious, he may be given hot drinks of tea or coffee.

Burns and Scalds.—These injuries present certain special features which necessitate special treatment. A burn is an injury caused by dry heat, such as a flame or a

piece of hot metal. A scald is an injury caused by moist heat, such as steam or hot water. The result in either case is the same, as is the treatment. The injured area should be covered up to exclude air, as this increases the pain. The bandages, however, must be prevented from adhering to the surface, as they would then be very painful to remove. Therefore, greasy dressings should be applied, using boracic ointment or carron oil. Failing these, any clean, greasy substance will do, such as olive oil, cold cream, vaseline or butter. If none of these is available, the bandages should be soaked in a solution of washing soda. The ideal treatment for burns is the application of tannic acid, and ointments containing this substance may be bought. Unfortunately, they tend to deteriorate if kept for a long time and, if such an ointment has its place in a school first-aid box, it should be renewed from time to time. It should be noted that a greasy application interferes with subsequent treatment by tannic acid. Clothing should be cut away if necessary, to avoid removing portions which are adherent to the burn or scald.

Insect Stings and Bites.—These, of course, are injuries of a minute character. They do not bleed very much, but they may be infected. If the affected place is vigorously sucked, infection is prevented and any poison introduced by the insect may be removed. Pain may be relieved by applying ammonia or a little washing soda. Some insects leave their stings behind and, when this occurs, the sting should be removed from the wound.

Fractures.—A fracture is an injury in which a bone is broken. The degree of damage varies from a crack in the bone to an actual division into two pieces. In a bad fracture the bone may be splintered. A fracture may be accompanied by an obvious external wound, but commonly there is no outward sign of the injury. It is not always easy to tell when a fracture has occurred and the diagnosis has to be based upon a consideration of probabilities. If a child falls heavily on to his arm or leg (especially if the limb is twisted under him as he falls), if a heavy blow is

received upon the body, or if a limb is subjected to powerful leverage across a desk or chair, a fracture is a distinct possibility. In any of these circumstances, if severe pain is felt, it is wise to assume that a fracture has occurred until the contrary is proved. Occasionally, a broken bone may permit a limb to be bent at an unusual place, or may allow mobility at a place where there is no joint. In these cases it is obvious that a fracture has occurred.

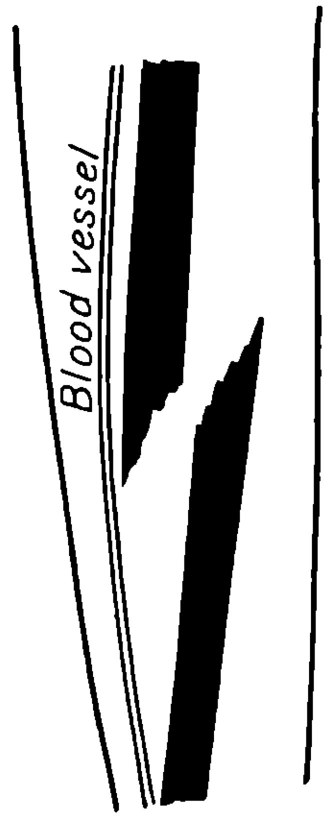


FIG. 133.—A fracture of the thigh.

Dangers of fractures.—Fig. 133 represents a leg in which the thigh bone has been broken. The two portions of the bone are out of their normal positions. The jagged ends may easily cause serious injury if the patient attempts to move the limb. Neighbouring muscles may be wounded, or a blood vessel, passing near to the ends of the bones, may be cut. At the very least, the bones may reunite in a faulty position unless the fracture receives proper treatment.

Treatment of fractures.—The first principle of first-aid in the case of a fracture is to keep the broken bones at rest, and so prevent further injury. This is achieved by applying

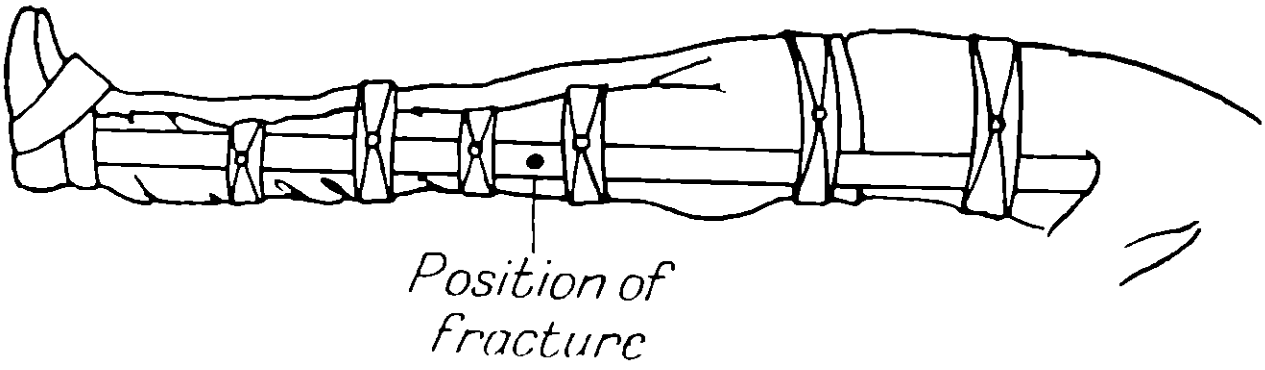


FIG. 134.—Position of splint for fracture of thigh (by permission from Davies' *Hygiene and Health Education*).

splints to the limb (fractures are most common in the limbs). A splint is any rigid object, such as a walking stick, a broom handle, or a small plank, and it should be applied according to the principles illustrated in Fig. 134. In this

case, the fracture is in the thigh as indicated. It would be no use applying a splint of very short length, as this would not control the movements of the thigh. The splint should extend, as shown in the figure, from the armpit to the ankle, and this is correct no matter where in the limb the fracture may be. The splint should be bound to the trunk by bandages and then bound to the injured limb at intervals, being suitably padded where it presses upon bony points, such as the ankle and hip. The manner of folding the bandage or the type of knot which is employed are entirely unimportant (although much attention is often given to these points), the one thing that matters being to keep the limb still. For further support, the injured limb may be bound against the sound limb or, better still, a smaller splint may be placed along the inner side of the leg. Muscles, pulling upon the broken bones, may cause the ends to override, with the result that the limb as a whole is shortened. In such a case, the limb should be gently pulled out to the same length as the uninjured one. The arm cannot be splinted as satisfactorily as the leg (at all events by amateurs) but the same general principle obtains, the longest splint practicable being applied to prevent movement of the broken bone. In the case of the arm, additional support may be afforded by making a sling, or by binding the limb to the chest. Fractures of the collar-bone, the ribs or the skull are best treated by laying the patient flat on his back, sending for a doctor, and meddling no further with the matter. Fractures other than these are not commonly found among children. It must be realized that the procedures described are only temporary measures and surgical aid should be obtained at once.

Shock is likely to occur in the case of a fracture, as in the case of other injuries, and should receive treatment as already explained.

Dislocations.—The bones of children are less brittle than those of adults, so that an injury which would lead to a broken bone in an adult often leads, in a child, to the bones being pulled apart at a joint. This is known as a

dislocation, and is represented diagrammatically in Fig. 135. A dislocation gives rise to pain, deformity at the joint, an unnatural position of the limb and lack of mobility at the joint. As in the case of a fracture, movement may increase the damage, and so splints should again be applied (or a sling in the case of the upper limb). Manipulation of the dislocation should only be attempted by a skilled person.

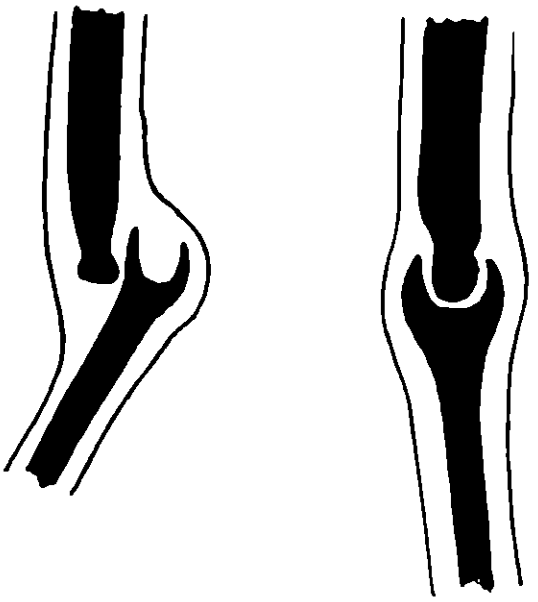


FIG. 135.—Dislocation of the elbow.

Sprains.—Another kind of joint injury is that known as a sprain or strain. It occurs as a result of a sharp wrench which stretches, or even tears, some of the joint ligaments. It is particularly common at the ankle joint, as represented in Fig. 136. The foot may be twisted in slipping off a kerbstone, in tripping over some object, or

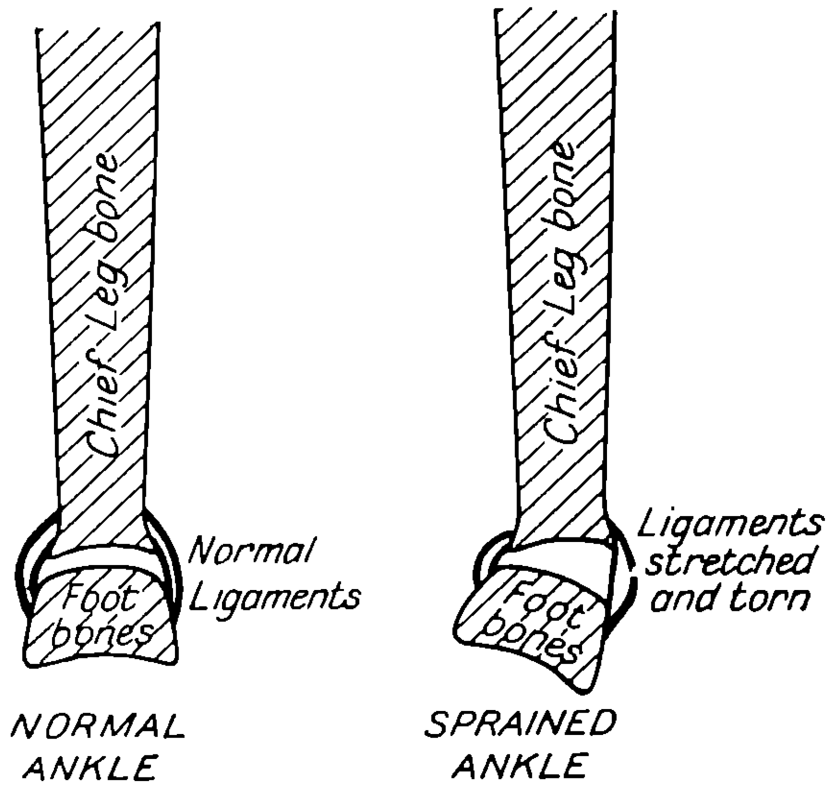


FIG. 136.—A sprained ankle.

in striking the ground forcibly when attempting to kick a ball. Any of these wrenches may produce a sprained ankle. As in other injuries of bones and joints, the first principles

of treatment are to prevent movement and to afford support. In the case of the ankle this is best done by applying a firm bandage wound like a figure of eight round the foot and lower leg. When the bandage is in position, cold water should be poured over it (and the ankle then dried) as this not only relieves pain, but causes the bandage to shrink and become tighter, so that it affords better support. The sprained ankle should be given complete rest and walking should not be attempted for a few days. With such treatment, cure is almost invariable and, if a sprained ankle does not respond to this treatment, a doctor should be consulted, in case there is something more than a sprain (such as a slight dislocation or a small fracture).

Loss of Consciousness

Consciousness may be lost for any one of a large number of reasons, but the commonest causes are fainting, an epileptic fit, concussion and sunstroke. Epilepsy has already been discussed (Chapter 28), but the other three will be dealt with here.

Fainting.—Fainting is loss of consciousness as a result of lack of blood supply to the brain. The capillaries of the head suddenly close up while those of other parts of the body dilate. This alters the distribution of the blood and leaves the brain temporarily unable to carry on its proper duties. This circulatory disturbance may occur as a result of severe pain, loss of blood from a wound, fear, distress, or other mental processes. The person who is about to faint becomes pale, as the blood drains away from the head, and feels giddy before actually losing consciousness. The obvious treatment of fainting is to aid the return of blood to the head, and this is best done by laying the patient flat on the ground, so that the influence of gravity no longer operates to keep blood from the brain. In the great majority of cases this simple treatment is all that is necessary to restore consciousness, but it is a slight advantage if the head can be actually lower than the rest of the body. No so-called stimulant should be poured down the throat

of an unconscious person as it may pass into the air passages and cause death by drowning. After consciousness has been restored, however, a drink of strong coffee or tea is generally appreciated. It is often recommended that the head of a fainting person should be brought forward between his knees. This position cramps the heart and lungs unnecessarily, does not entirely cancel out the influence of gravity upon the body, and has nothing to recommend it in preference to the prone position already described.

Concussion.—Concussion or stunning means unconsciousness following a fall or blow on the head which has jarred the brain. The recognition of this condition is generally easy from the nature of the accident. The first-aid treatment is also simple. The patient should be left lying where he fell and, beyond straightening him out into a comfortable position, no treatment or interference of any description should be attempted. If serious damage has been done to the brain, if the skull has been fractured, or if bleeding is taking place inside the head, the injury may be made very much worse by moving the patient unnecessarily. If the accident takes place out of doors in the rain, or in other special circumstances, it may be necessary to carry the patient elsewhere, but whenever possible he should be allowed to remain where he fell until a doctor has seen him. It is, of course, permissible to cover him up, and it can do no harm (and may do good) to lay a cold water bandage on the head, but these are the limits of first-aid treatment in this condition.

Sunstroke.—Exposure to the sun's rays may lead to a form of fainting which is known as sunstroke. Exposure to extreme heat of any description may give rise to a similar condition called *heat-stroke*. The first symptoms of either of these complaints are headache and giddiness. Loss of consciousness may then follow. The treatment is, as in ordinary fainting, to lay the patient flat on his back, but, as unconsciousness has occurred as a result of heat, it is reasonable to try to cool him. He should therefore be

removed to the shade or to a cool room, and the clothing should be loosened or largely removed. The head and neck should be bathed in cold water or rubbed with ice if this is available. Occasionally, sunstroke or heat-stroke lead to serious after-effects, so that it is wise to send for a doctor if recovery does not take place quickly.

Drowning.—A person who has suffered prolonged immersion in water is not only unconscious, but may have ceased to breathe. The body is also chilled, and water may have got into the air passages from attempts at breathing made while under the surface. First-aid treatment must

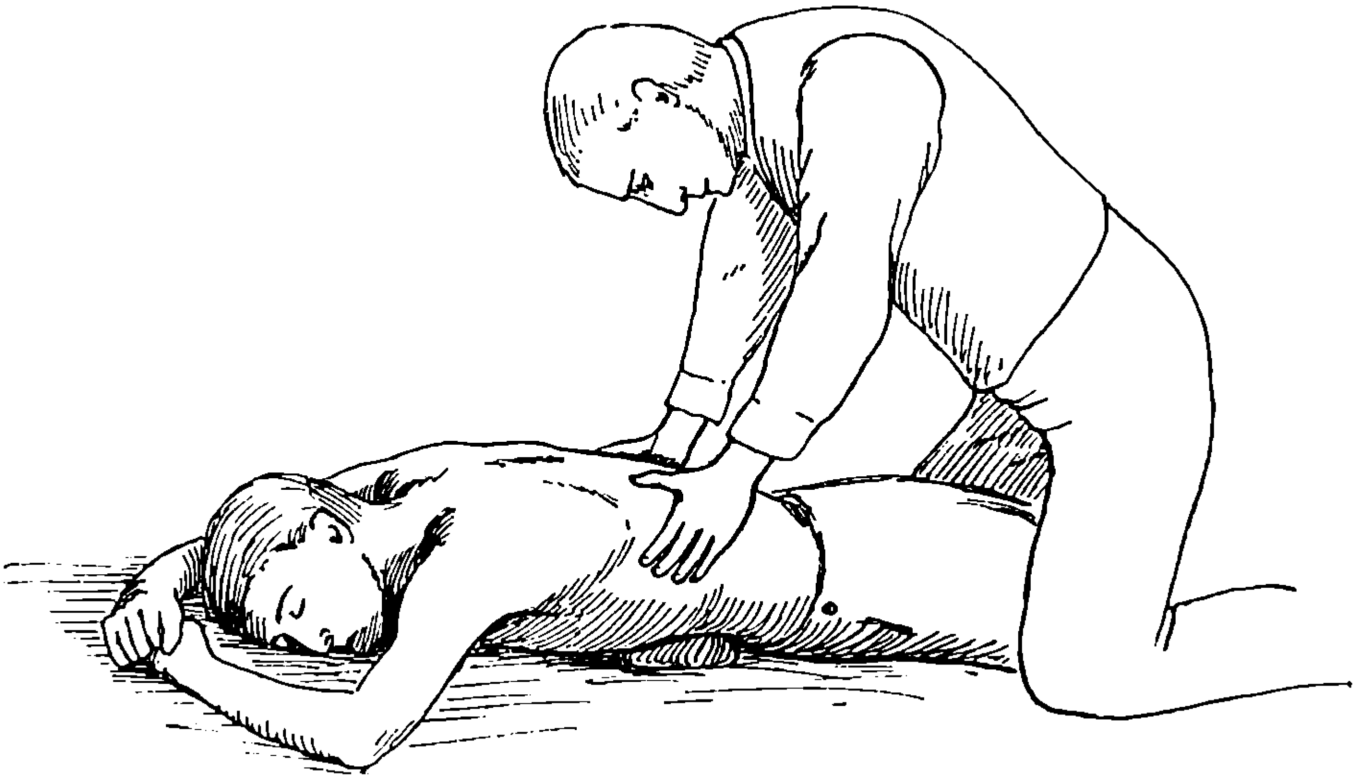


FIG. 137.—Artificial respiration.

take into account each of these points. A doctor should be sent for immediately and hot bottles, coats, rugs or blankets should be used to warm the patient. In the absence of any of these, the body should be vigorously massaged. While these things are being done, the person who has taken charge of the first-aid operations should attend to the two most important things, getting rid of the water and restarting the breathing. The patient should be turned face downwards, after removing any obvious obstruction (such as weeds or seaweed) from the mouth and nose. Standing astride of the patient, the operator should pass his hands round the patient's hips and clasp them together over the

lower abdomen. The patient should then be jerked up off the ground several times. The heaving thus produced effectively pumps water out of the stomach and respiratory passages. Artificial respiration should now be commenced. The operator should kneel down still astride of the patient, and place his hands over the lower ribs, as shown in Fig. 137. On leaning forward, so that the weight is on the hands, the lungs are compressed. On relaxing the pressure, the lungs expand. The natural movements of breathing are thus imitated and air is alternately drawn into and expelled from the lungs. The movements should be carried out at the rate of eighteen times a minute, and should be continued (by relays of operators) until natural breathing recommences or until a doctor pronounces life extinct. It is a great mistake to cease artificial respiration too soon. Breathing has begun again, in seemingly hopeless cases, after artificial respiration has gone on for several hours.

Poisoning

An enormous number of substances are poisonous to human beings but, from the point of view of first-aid, all the common poisons may be divided into two categories: corrosive poisons (those which eat away the tissues of the body) and non-corrosive poisons (all the others). The corrosive poisons are injurious if they come into contact with the skin as well as when they are swallowed.

Non-corrosive poisons.—It is better to consider this group first in order to appreciate the differences in the treatment of the two types of poisoning. In all cases the first thing to do is to send for a doctor. The messenger should be sufficiently intelligent and free from breathless panic to be able to give the doctor some idea of what has occurred. (" Some red berries have been eaten." " Some disinfectant has been drunk." " An overdose of a sleeping draught has been taken.") This gives the doctor some idea of what drugs and instruments to take and may be the means of saving valuable time. Having sent for the doctor the next step is to save any of the poison which remains and

put it in a safe place. The doctor will want to see it and so will the coroner if the case proves fatal. Next comes the treatment of the patient. The poison has been swallowed and is in the patient's stomach. If it is quickly got out of him it can do no further harm, so that the obvious thing to do is to make him vomit. Vomiting can be induced by tickling the back of the throat with the finger or a feather or by giving a nauseous draught, such as a desertspoonful of mustard or a tablespoonful of salt in a tumbler of water. Even when the poison has been removed in this way some of its effects may persist. Many poisonous plants produce drowsiness which may go on to fatal unconsciousness unless counteracted. In such a case the patient should be kept awake by slapping or pinching him, walking him about vigorously or by giving him strong, hot coffee. Some poisons produce excitement and delirium, and these symptoms should be counteracted by putting the patient in a quiet, dark room, away from excited spectators, and soothing him as much as possible.

Corrosive poisons.—Acids (such as nitric, sulphuric or carbolic) and alkalies (such as ammonia or caustic soda) act as poisons by eating away or corroding those parts of the body with which they come in contact. Thus, if they are swallowed, they burn the lips and mouth and this gives some clue to the type of poisoning which has taken place. When a corrosive poison has been swallowed vomiting must not be induced, in case the stomach, already softened by the poison, be torn or injured. Ideally, the poison might be neutralized by giving a suitable antidote. If an acid has been taken an alkali, such as bicarbonate of soda, could be given in water. If an alkali has been taken an acid, such as vinegar, could be used. Often, however, the proper antidote is not at hand and, if it is, it is impossible to know what strength to use. Even if the antidote were made up to the correct strength to neutralize the poison, allowance could not be made for the dilution which would occur within the stomach. Instead of wasting valuable time attempting neutralization, the best thing to do in a case of corrosive

poisoning is to give the patient plenty of water to drink, thus diluting the poison and rendering it relatively harmless.

Corrosive poisons on the skin.—A child may have an acid or alkali splashed upon his skin in a laboratory. Here again it is not wise to waste time concocting an antidote. The best treatment is to wash the skin immediately in plenty of running water. If the corrosive substance has already produced a burn, this should be treated like any other burn after the initial washing

Foreign Bodies

Foreign bodies in the apertures of the head may constitute emergencies needing first-aid treatment. Children sometimes introduce small objects into their ears or noses. In such a case, although the condition may be painful, it rarely demands urgent treatment. It is much better to take the child to a doctor or hospital, as unskilled attempts to remove the foreign body with inadequate instruments may only force it further into the nose or ear and do more damage. If an insect gets into the ear (a relatively rare event) it may be drowned and floated out by introducing a little warm olive oil.

Foreign body in the eye.—A foreign body in the eye is much more painful and dangerous than one in the nose or ear. Even a tiny scar, caused by a very slight injury, may seriously interfere with vision. The foreign body should be extracted with the corner of a handkerchief in the familiar manner, but if it is behind the upper lid it will be found useful to roll this lid upwards round a matchstick in order to expose the inner surface. If the foreign body cannot be located, a doctor should be consulted. If a child gets a fragment of metal in the eye in a workshop, he should be taken quickly to a hospital where a suitable electro-magnet can be used to extract it. If not done without loss of time such a metal fragment may travel to an inaccessible depth in the eye.

Foreign body in the throat.—If a foreign body is swallowed and sticks in the throat it may produce death through suffocation. Immediately attempt to hook it up with the finger, and if this fails turn the child upside down and slap him vigorously between the shoulders to make him cough.

Most emergencies are not so urgent as people are inclined to suppose, and first-aid is more likely to be effective if carried out calmly and with due thought than if hurried through in a panic. There are two exceptions to this general statement. If a corrosive poison has been swallowed or if a foreign body has lodged in the throat every second is valuable and treatment should be applied without any loss of time. Fortunately, these two emergencies are amongst the least common in school life.

The School First-Aid Box

It is desirable for any institution, including a school, to have a first-aid box. The articles which this box should contain have already been indicated in describing their use in the various emergencies. They may be briefly summarized (and some additional ones noted) here.

Bandages.	Surgical plaster.
Boracic lint.	Cotton wool.
Safety pins.	Tannic acid ointment.
Ammonia.	Olive oil.
Scissors.	Tincture of iodine.
Mustard and a desertspoon.	Tweezers for splinters.
Sticks suitable for splints and tourniquets.	

In this chapter, emergencies have been reduced to as few groups as possible, and only the simplest treatment has been described. If the teacher attempts to remember a great deal of complicated treatment for a large number of accidents, the result may be mental confusion or imperfect memory of details when an emergency actually occurs. First-aid is not required every day but only at comparatively infrequent intervals, but if a few clearly-defined principles of treatment are well understood, they may easily be remembered and applied in a large variety of different circumstances when need arises.

PART V

HYGIENE OF THE SCHOOL

CHAPTER 30

SCHOOL BUILDINGS AND EQUIPMENT

ALTHOUGH teachers cannot ordinarily influence the construction and equipment of the school, they should nevertheless know something about these things.

The Building. ***Central hall plan.***—Schools erected about the beginning of the present century were commonly built upon the central hall plan, so-called because the main feature is a hall with class-rooms grouped round it (Fig. 138). Such a school is compact and does not extend over a great deal of land, a matter of importance in large cities where land is dear. Several stories of class-rooms may be grouped round the hall, opening off balconies, or each floor may have its own hall, these being set one above the other. If the one hall extends up to the roof, it may be entirely surrounded by class-rooms and illuminated by skylights. If each floor has its own hall, class-rooms can only be built on three sides, the fourth being used for windows opening into the halls.

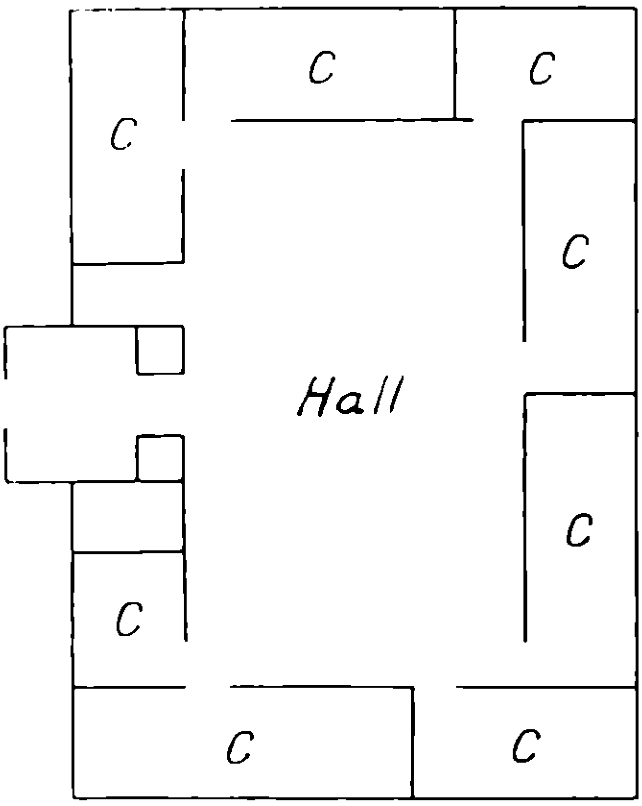


FIG. 138.—The Central Hall Plan. (C = class-room.)

Many schools of this type have a flat roof which, in some cases, is used as a playground. Another advantage claimed for the central hall school is that the head teacher, occupying a desk in the hall, is well placed to supervise the work of the school : a claim of doubtful value.

Hygienically, these schools present certain disadvantages. The class-rooms (with the exception of those at the corners) have only one wall on the exterior of the building, and so the space available for windows is limited. This sometimes makes the lighting inadequate, and interferes with ventilation. In any case, efficient cross ventilation is impossible in the rooms of a building of this type, as one side of the room opens on to the hall, which is a well of stagnant air, generally full of dust. Further, the rooms on the north side of the building never receive any sunlight during school hours, and so tend to be cold and dreary. Those on the south may receive too much sun in summer and become unbearably hot. This may be remedied to some extent by building the school with an angle, rather than a side, facing each of the cardinal points of the compass. Another disadvantage of this plan is that when the hall is used for assemblies, physical training or singing, the noise interferes with work in all the class-rooms.

Pavilion plan.—The pavilion plan (Fig. 139) is an attempt to remedy some of the defects inherent in the central hall school. Schools of this type are also known as Staffordshire schools, from the county in which the idea originated. The hall, cloak-rooms, teachers' rooms and the like, form one block, while the class-rooms form another block, meeting the first at an angle. The exact shape of the school naturally varies, but the class-rooms are always so arranged that each has at least two walls opening to the fresh air. This increases the amount of daylight which can be admitted, and greatly facilitates efficient ventilation. For convenience in reaching the class-rooms in bad weather, a verandah or covered way should extend along one side, preferably the north. This should be an open passage, and in no sense a closed corridor, or the object of the building is defeated. A pavilion school may be built in several stories,

but single-storied buildings are more usual, as there are disadvantages about staircases in schools. The school tends to spread over a good deal of land and so may be expensive to build. It is also difficult to heat these buildings as some of the rooms are a long way from the boiler and hot water pipes have to travel a considerable distance to reach them. Electric heating (described in Chapter 31) overcomes this difficulty.

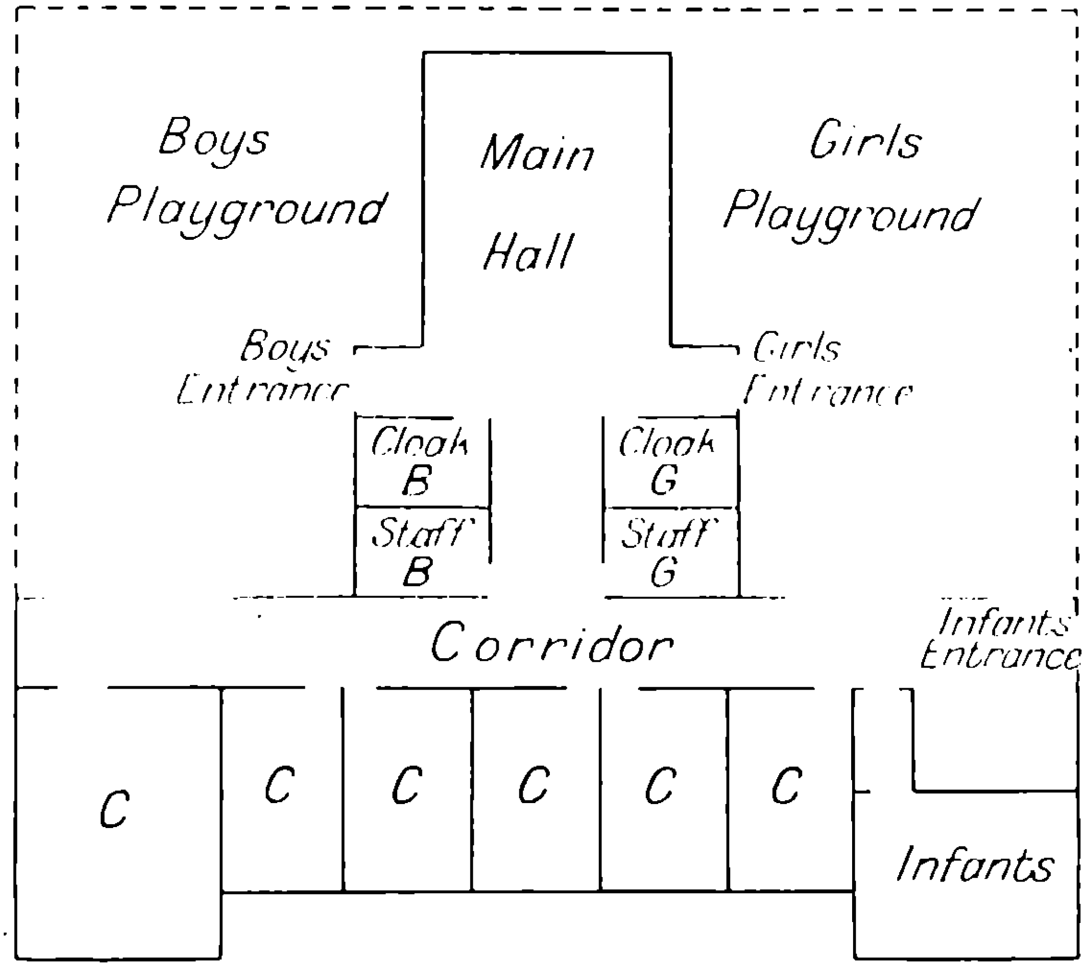


FIG. 139.—The Pavilion Plan.

Courtyard plan.—A third type of school is one in which the class-rooms are built round a rectangular space which is not roofed in to form a hall, but is left as an open court, playground or grass plot (Fig. 140). This allows light and air to gain access to the class-rooms more effectively than in the central hall type, but not as effectively as in a Staffordshire school. The cloak-rooms and assembly hall should be placed on the north side of the court or, if there are two departments in the school, the hall (or halls) may separate them and subdivide the central courtyard into

two lesser spaces. This plan is of use in that it combines a reasonable degree of airiness with compactness.

The Class-Room. ***Structure.***—A class-room should be of such a size as to allow from ten to twelve square feet of floor space per child in an elementary school, and sixteen square feet in a secondary school, where the children are older. The room should be twelve feet high, but any greater height is not of much value from the point of view of airiness, and is a disadvantage from the point of view of heating. The best shape for a class-room is oblong, the

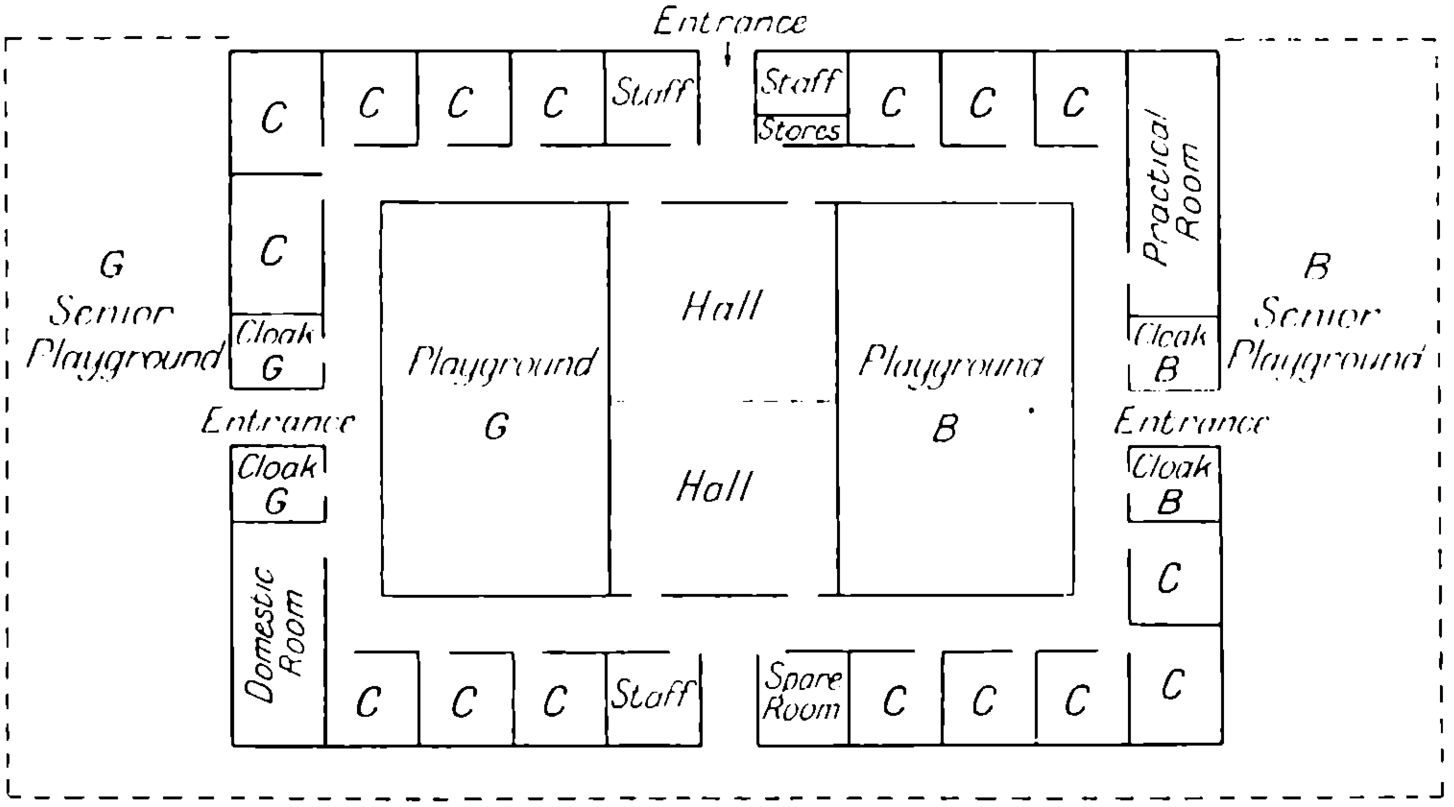


FIG. 140.—The Courtyard Plan.
(B = boys; G = girls.)

rows of desks being parallel with the shorter walls. The room should not be wider than about twenty feet, or else some children will have difficulty in seeing the blackboard. Plainness in design is desirable, without any useless projections or awkward corners to harbour dust. Bareness, however, should be avoided by the decoration of the walls and by the introduction of such things as pictures. Wooden floors are best, as they are not cold to the feet. Their noisiness may be diminished by using wood blocks rather than planks. The floor should be treated from time to time with a suitable dust-binding preparation.

Equipment.—Desks have already been discussed in Chapter 19. Other important items of class-room furniture are cupboards (to hold books and apparatus) and the blackboard. The blackboard should have a matt surface and is best made of wood, painted black. It should be suitably placed with regard to light, both day and artificial, and beneath the board there should be a ledge to catch chalk-dust. Almost dustless chalk can be obtained but it is somewhat expensive.

The Cloak-Room.—Cloak-rooms must be provided for children of different ages and sex, and facilities should exist for washing (see Chapter 17), drinking and hanging garments. The most hygienic drinking device is a fountain which projects a weak jet of water upwards, to which the lips may be applied without the necessity for using a cup. Pegs for clothes should be at heights suitable for the children who have to use them, with a space of twelve inches between each peg in the case of boys and eighteen inches in the case of girls and infants. Adequate ventilation is essential in the cloak-room to aid the drying of clothes in wet weather.

The Playground.—The area of the playground should be such as to allow from sixteen to thirty square feet per child according to age. Separate playgrounds are desirable for boys and girls, but the girls' playground may be shared by infants. A loose surface, such as gravel or cinders, causes much dirt to be brought into the school, and is a source of danger to children who fall and cut themselves. A smooth, impervious covering of concrete or asphalt is better, but is liable to be slippery in frosty weather.

Sanitation.—It is customary for closets to be built away from the school itself, at all events in the case of elementary schools. There does not appear to be any adequate reason for this practice. Where a water supply and proper sewers are available ordinary wash-down closets are much to be preferred to any other type, although, in some cases, children may need to be trained to use them

properly. Where there is a water supply but no system of sewers the wash-down closet can still be used but must be drained to a cesspool. This is simply an underground storage chamber in which sewage accumulates. It must, of course, be emptied from time to time by means of a pump and tank wagon. If no water is laid on to the school recourse must be had to some form of dry closet. The most useful form is the earth closet into which about $1\frac{1}{2}$ lbs. of dry earth is thrown after use or, in some closets, the earth is discharged automatically. Certain germs which are contained in the soil destroy the excreta.

There should be one closet to thirty boys, one to fifteen infants, and one to ten girls. If the school contains a large number of children these proportions need not be maintained. In many cases it will be sufficient to have one closet to every sixty boys, one to every forty infants, and one to thirty girls. In addition, there should be ten feet of urinal space to each hundred boys. It is desirable for the walls of all sanitary conveniences to be made of impervious material such as glazed brick, and closet doors should be a few inches short at the top and bottom to provide for ventilation. The doors of closets used by young children should be an inch or two narrower than the doorway, thus leaving a space at each edge and so preventing the trapping of hands.

CHAPTER 31

VENTILATION, HEATING AND LIGHTING

THE provision of correct and adequate ventilation in a school is not, perhaps, of any greater importance than the provision of a satisfactory system of drainage, proper lighting or interior equipment. Nevertheless it is more important for a teacher to have a knowledge of the principles of good ventilation than of any of these other things, since ventilation is something which the teacher can directly influence, an aspect of hygiene which can be specifically taught to children. If the school is badly designed, badly lighted or suffers from defective sanitation, teacher and scholars must usually accept this state of affairs; but in the matter of ventilation they can play an active part and, by adequate knowledge, get the most out of whatever is provided by the Authorities. The subject will therefore be discussed at some length in this chapter.

Composition of Air.—Before considering the subject of ventilation some preliminary knowledge of the composition of air is necessary. Table XXIII shows the composition

TABLE XXIII.—THE COMPOSITION OF AIR

Constituent.	*Fresh Air.* Per cent.	*Expired Air.* Per cent.
Nitrogen	79·00	79·00
Oxygen . .	20·00	16·00
Carbon dioxide	0·04	4·00
Other gases	traces	traces
Moisture	variable	increased
Temperature	,,	

both of fresh, outdoor air and of air which has been breathed and expired by human beings. The great bulk of air con-

sists of a gas called nitrogen. This gas is colourless (and consequently invisible), odourless, tasteless, non-poisonous, but at the same time is of no use for supporting life. Mixed with this gas is another, called oxygen, forming about 20 per cent. of the atmosphere, at all events at sea level and the low altitudes commonly inhabited by human beings. Oxygen is essential to living creatures, and when we breathe air our bodies extract from it a certain amount of this gas. Expired air is about 4 per cent. poorer in oxygen than fresh air. In addition to the gases already mentioned the atmosphere commonly contains small traces of others such as argon, krypton, neon, xenon and (in the neighbourhood of manufacturing towns) ammonia and sulphuric acid. Amongst these minor constituents of air is the gas carbon dioxide, present to the extent of about 0·04 per cent. When air is breathed out of the body the 4 per cent. of oxygen which has disappeared is represented by 4 per cent. of carbon dioxide.

Vitiation of the Atmosphere.—At one time it was thought that the ill-effects of bad ventilation were due to lack of oxygen in the air. It has been shown, however, that people do not feel uncomfortable in an atmosphere containing as little as 12 per cent. of oxygen and, in ordinary occupied rooms, the percentage never falls as low as this. Indeed, many towns, situated at high altitudes, where the oxygen content of the air is diminished, are health resorts. It was also supposed that carbon dioxide was a poisonous substance directly responsible for the unpleasant feelings experienced in a badly ventilated room. It is now known that this idea is false since human beings do not necessarily feel harmful effects from eight or even ten times the amount of carbon dioxide which is ordinarily present in a " stuffy " atmosphere.

Since carbon dioxide is not itself an important factor in ventilation people have sought elsewhere for the explanation of stuffiness. The Table shows that, in addition to the alteration in chemical composition when air has been used by the body, fresh air is both dryer and cooler than used air.

The interior of the body is, of course, both warm and wet, so expired air is warmer and wetter than fresh air. It is these factors of warmth and wetness which are responsible for the unpleasantness of a badly ventilated atmosphere and, as long as the air can be kept reasonably dry and reasonably cool, people feel comfortable in a room irrespective of the carbon dioxide present. Certain experiments and experiences show the truth of this view. For example, people may be placed in a small, badly ventilated room and after a time they feel uncomfortable. If an electric fan is then set going so that the air is set in motion, they no longer experience discomfort although the actual composition of the air has not been altered. Setting it in motion has cooled it and prevented it from becoming too

TABLE XXIV.—METHODS OF VENTILATION

Natural.—Diffusion.		
	Wind:	perflation.
		aspiration.
	Convection.	
Artificial.—Propulsion (plenum).		
	Extraction (vacuum).	
	Balance (combined).	

moist. In summer people sit in rooms with the windows wide open and there should be no lack of ventilation, yet they feel uncomfortable simply because the air is warm and moist. To relieve their discomfort they fan themselves or take other measures to create a breeze and the air, being set in motion, becomes cooler and dryer and consequently more bearable. Good ventilation, therefore, has as its aims, first, to keep the air moving (without, of course, creating a draught); second, to keep the air cool (about 60° F.), and third, to keep the air reasonably dry.

Methods of Ventilation.—Methods of ventilation may be divided into two main groups called natural and artificial. Natural methods are those in which no moving machinery is employed. Artificial or mechanical methods are those in which machinery is used, generally in the form of a fan. Table XXIV shows how these main groups of methods may

be further sub-divided. In schools the natural methods of ventilating are to be preferred to the artificial. Simple devices are employed which may readily be operated by the children themselves and this forms a valuable training in practical hygiene. The artificial or mechanical systems are generally fairly expensive to instal and maintain and, being more complicated, are more liable to get out of order. In the following paragraphs the different methods of ventilating are considered in some detail.

Diffusion.—If two gases, such as oxygen and nitrogen, are introduced into a room, it is not found that the oxygen settles down in one part of the room and the nitrogen in another: each of them spreads evenly throughout and fills all the available space. This phenomenon is termed diffusion. The rooms in which people live and work are very rarely airtight: there are minute spaces round the window-frames, gaps round the doors, and the bricks of the walls are themselves somewhat porous. Consequently the outdoor air is able to diffuse into the room and the indoor air is able to diffuse out, and so the air inside tends in time to assume the composition of that outside. By diffusion alone, therefore, a room may be ventilated. Usually, however, this process is too slow to be of much practical use. If a class-room were ventilated only by diffusion it might take a week for a pure atmosphere to be re-established after a day's occupation.

The Wind.—A more effective method of natural ventilation is to make use of the action of the wind which ventilates in two ways, by *aspiration* and *perflation.* When the wind is in the right quarter it blows in through an open window and this is termed perflation. On other occasions the wind may blow past the window without actually blowing in, thereby creating suction, drawing air out of the room, and this is termed aspiration. When the wind blows over a chimney-pot it often sucks air out of the chimney and consequently out of the room connected to that chimney and this again is an example of aspiration.

Convection.—Although the wind is a better ventilating agent than mere diffusion yet it is not sufficiently constant to be relied upon entirely, for several consecutive days may happen to be practically windless when neither perflation nor aspiration will occur. It is well known that most substances, when heated, expand, and the gases of which the air is composed obey this natural law. When air is heated it expands and becomes lighter. Being lighter it

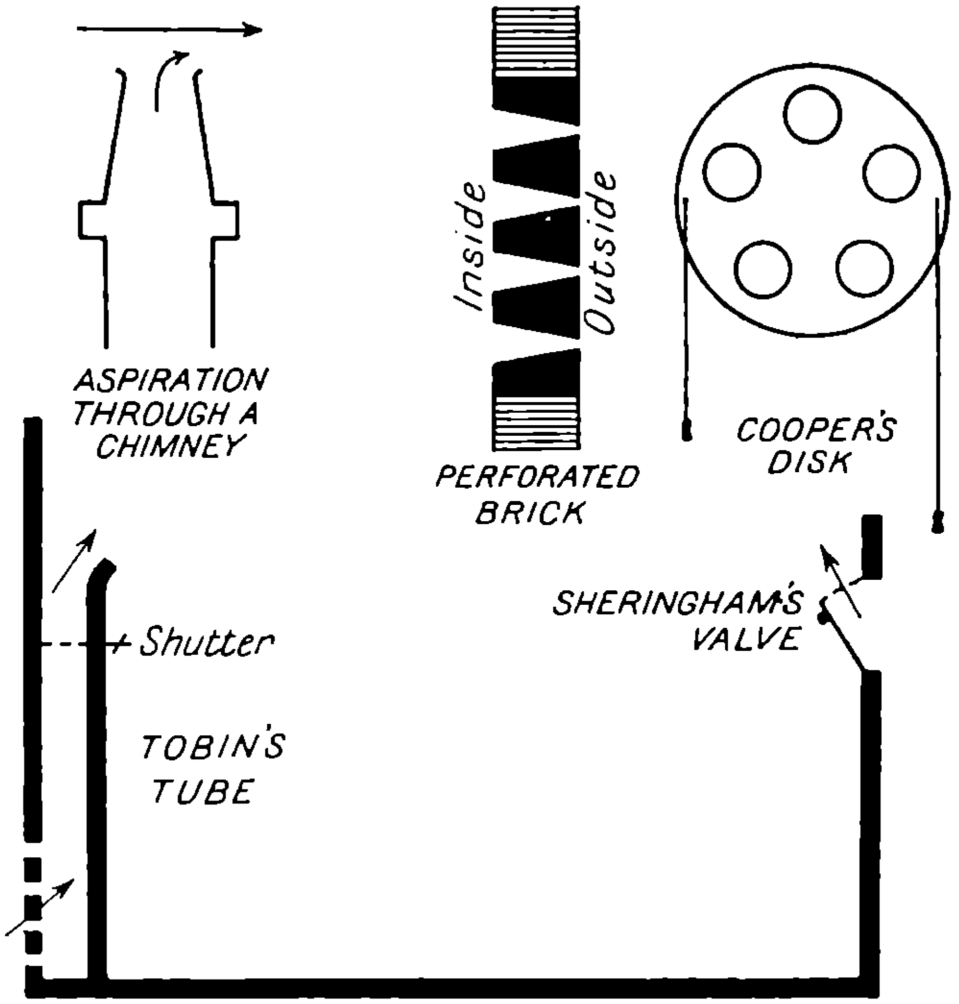


FIG. 141.—Ventilating devices.

tends to rise, while cold air, conversely, sinks. This movement of masses of air of differing temperature is termed convection. Whenever people are assembled in a room the heat of their bodies warms the air near to the ground and this rises, while fresh air flows in underneath doors or through ventilating apertures to take its place. This type of ventilation may be assisted by deliberately warming the air near the floor by suitable radiators or hot-water pipes.

Ventilating Devices.—Most systems of natural ventilation make use of diffusion, wind action and convection

combined together, and for these purposes a variety of pieces of apparatus has been devised. Some of them are shown in Figs. 141 and 142. As the wind blows over a chimney pot it aspirates air from the room beneath. When a fire is burning in the fireplace it creates an ascending current of hot air, a convection current, so that a chimney may act as a ventilating agent in each of these ways or in both at the same time. A perforated brick may be built

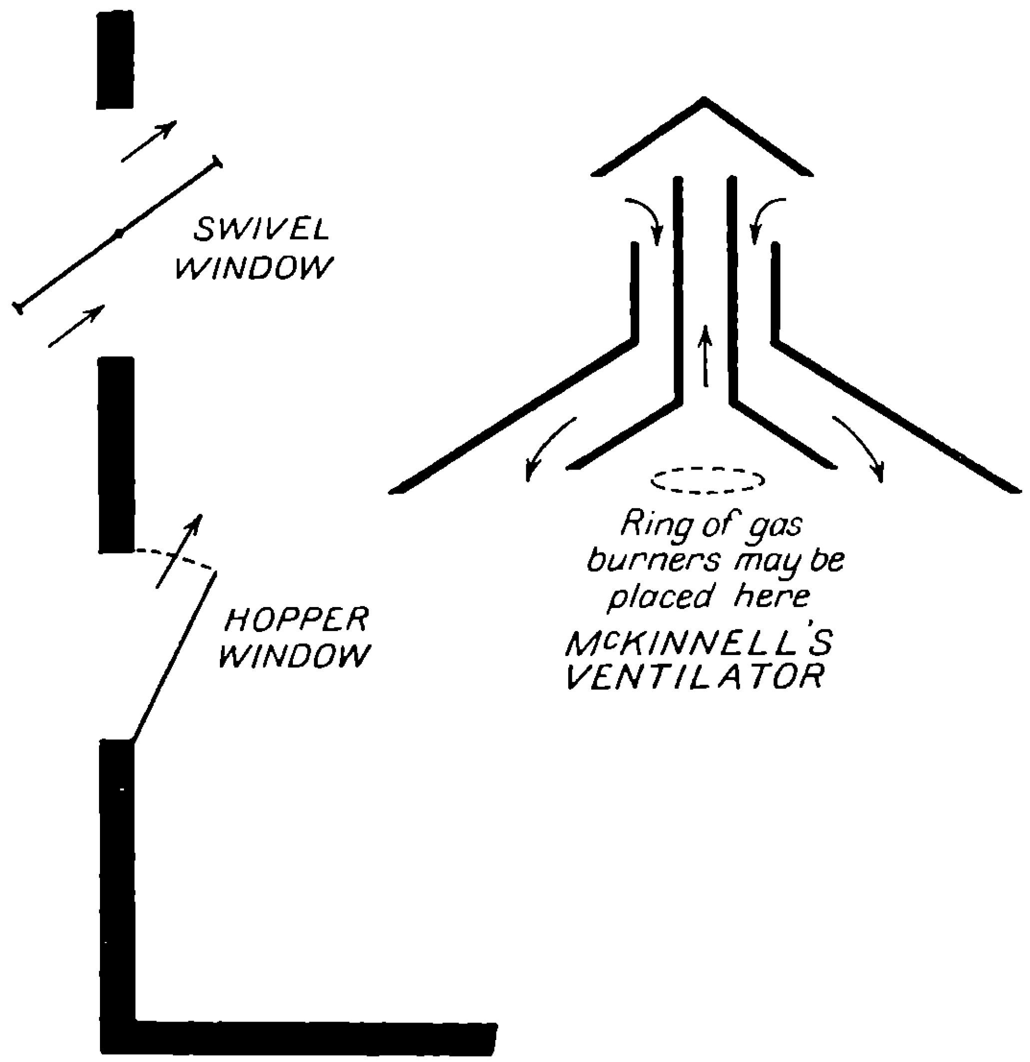


Fig. 142.—Further ventilating devices.

into the lower part of a room but is more commonly employed for ventilating the spaces under the floors of rooms. The holes penetrating the brick are not usually cylindrical in section but somewhat conical, as seen in the diagram, with a smaller opening on the outside than that on the inner. This arrangement decreases the speed of the air as it passes through the brick and so prevents draughts. Cooper's Disc is a ventilating device commonly seen in offices and banks. It consists of a disc of plate glass perforated by five or six holes. The disc is fastened on to a window-pane

by a pivot in its centre, and the window-pane is itself perforated by holes. By means of cords the disc can be rotated to bring its holes opposite those in the fixed window-pane beneath, and in this way fresh air is admitted from the outside. When a perforated brick is used to admit air into a room it may happen that the wind blows in too violently for the comfort of the occupants. Tobin's tube is a device designed to overcome this defect, the perforated brick opening into a tube which conveys the air upwards and finally admits it into the room at a height of five or six feet, that is, above the heads of the occupants. The incoming cold air then falls down more gradually upon the people in the room without creating a definite draught. Usually the tube contains a shutter worked by a handle in order that the amount of air entering the room can be regulated. Sheringham's valve is another device for admitting cool air without causing a direct draught. It consists of a metal flap usually placed high up in the wall and controlled by means of cords. As before, the incoming air is diverted upwards. The hopper and swivel windows shown in the figure are too well known to require description. They are, again, devices for deflecting the incoming cold air upwards. McKinnel's ventilator is used in assembly halls rather than in class-rooms. It consists of two concentric cylinders projecting through the roof, the inner cylinder somewhat resembling an inverted funnel. A suitable cover keeps out the rain without interfering with the passage of air. The warm air of the room rises towards the funnel and escapes through the inner cylinder, cold air flowing in through the outer cylinder to take its place. Sometimes a ring of gas burners is suspended immediately below the funnel of the inner cylinder in order to create a more definite current of hot air.

The essential features of any natural method of ventilation are two openings: one low down to admit air and one high up for the exit of warm air. These openings may be filled in by any of the devices just described and, in the case of the lower opening, the incoming air should be deflected upward to avoid a direct draught.

The Plenum System.—This system of artificial ventilation is shown in Fig. 143. A fan, usually situated in the basement of the building, draws the air down a shaft from a point high up on the roof, and pumps it to all parts of the building through a series of pipes. Before reaching the fan the air is made to pass through a screen of sacking which is kept moistened with water, and this device filters

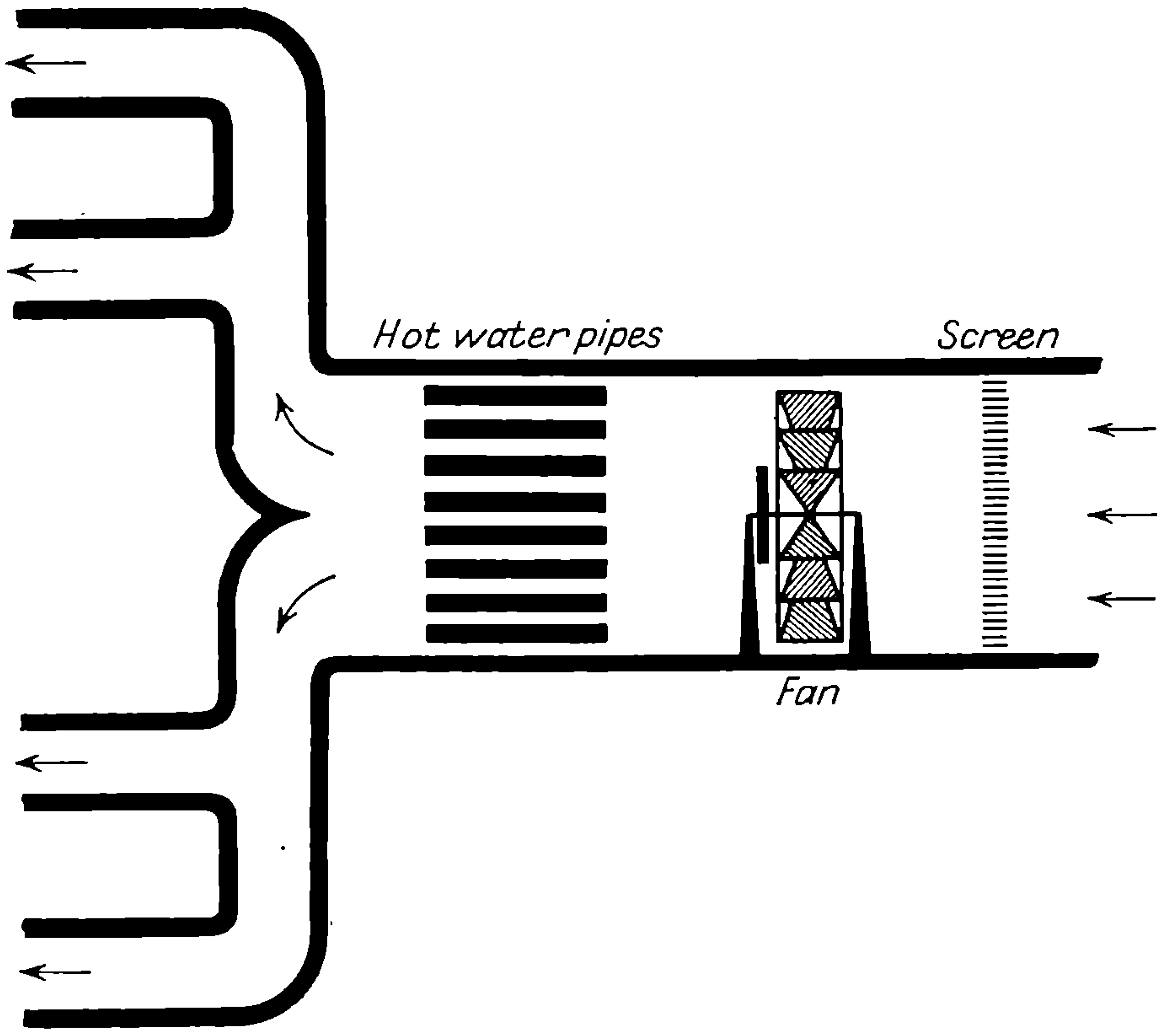


FIG. 143.—The plenum system.

the air from gross impurities. On leaving the fan the air passes over a series of hot-water pipes and this combines ventilation with the heating of the school, although, as has been explained, it is not necessarily a good thing to heat the air. The advantage of this system is that the atmosphere of the school can be very accurately controlled. Air can be admitted to the class-rooms at any speed or at any temperature which may be desired and, because of the filtration which it undergoes, the air is reasonably clean.

The disadvantages, however, are numerous. The apparatus is expensive to install and to maintain. The fan tends to be somewhat noisy and the noise is conveyed along the air-pipes to each room. Frequently an air-pipe leads to the first room on a corridor, the air passes through this room and into the next room through a grating, and in like manner through each room of that particular corridor. If the windows in the first room are open the air tends to escape through them, and so the remaining rooms are not properly ventilated. Consequently, when a school is ventilated by means of the plenum system, the windows have to be made unopenable, which constitutes a very bad object-lesson to the children. If the fan gets out of order and breaks down no ventilation of the building is possible, since the windows cannot be opened. A plenum is the opposite of a vacuum and means a space filled with matter—in this case, air.

The Extraction or Vacuum System.—This is the reverse of the one just described. A fan near the roof draws air out of the rooms instead of pumping it in. This system suffers from the same drawbacks as the plenum system from the point of view of expense and trouble and, of course, the air entering the building cannot be in any sense controlled.

The Balance System.—This is a combination of the two foregoing ones, one fan pumping fresh air into the building and another drawing foul air out. The same disadvantages are found in connection with this system as those described for the plenum system.

It is possible to extract foul air from a building without using any mechanical device such as a fan. Some such method as that used in the House of Commons may be employed. This system is shown in Fig. 144, and it depends largely upon convection. A fire at the base of the clock tower creates a strong upward draught which draws air out of the House.

Heating.—Coal fires and stoves are too troublesome for extensive use in schools. They are also too local in their

range of heating. The latter objection applies to gas fires and electric radiators as well. The most used systems of school heating are those which employ steam or hot water. Steam and high-pressure hot-water systems are not really desirable as, amongst other disadvantages, the pipes become

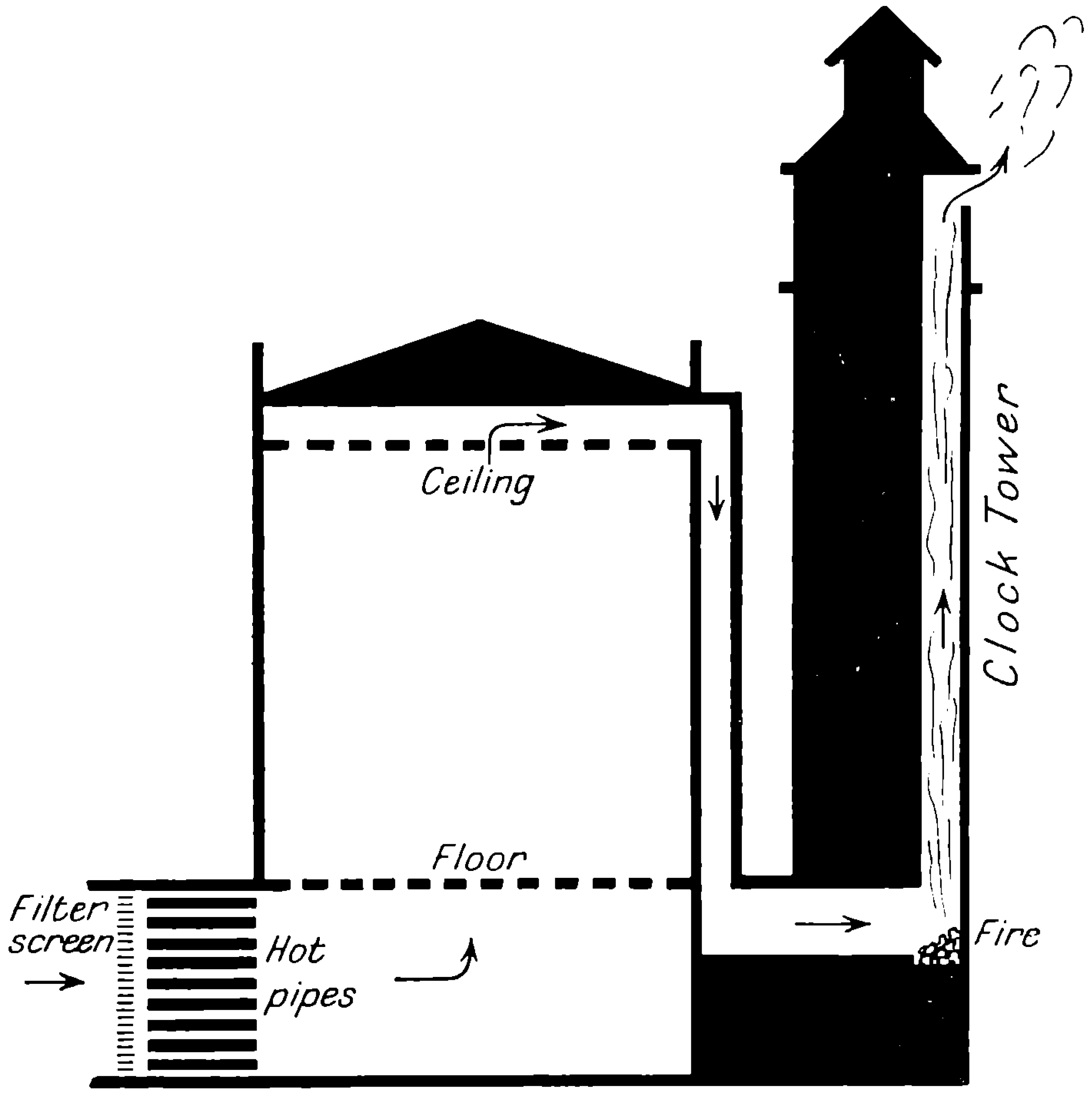


FIG. 144.—The ventilating system of the House of Commons.

dangerously hot. A medium or low-pressure hot-water system is free from this disadvantage. The water runs in pipes round the building, and the pipes may be concentrated in the form of radiators at intervals. In some modern installations the pipes are concealed beneath the floor, or within the walls or ceiling. The chief disadvantage about any kind of steam or water-heating system is that the air

is heated and this, as has been explained, is not a desirable thing. The disadvantage is intensified in a really well ventilated school, for the air, being continually moved out of the class-rooms, carries the heat with it. This drawback can be entirely avoided by using a new device in which metal plates are fixed to the upper parts of the walls and, by means of electricity, are made to emit radiant heat. The radiations do not heat the air, but only the bodies of the people with which they come in contact. This type of installation is, however, dear.

Whatever form of heating is employed, the temperature within the school should be about 60° F. or a little less.

Lighting.—The lighting of class-rooms has been discussed in Chapter 20.

CHAPTER 32

SPECIAL SCHOOLS AND SPECIAL EDUCATION

CHILDREN who require special education may be divided into the groups which are set out in Table XXV. The

TABLE XXV.—GROUPS OF CHILDREN REQUIRING SPECIAL EDUCATION

1. Blind.
2. Deaf.
3. Physically defective.
4. Epileptic.
5. Mentally defective.

names assigned to these groups are, for the most part, self-explanatory. Blindness and deafness are physical defects, it is true, but the term physically defective is usually applied only in a more limited sense to crippled children. The special education of children with defective vision and defective hearing has been dealt with in earlier chapters. Epilepsy has also been referred to as a complaint which interferes with normal education. In this chapter the education of the physically and mentally defective will be considered.

Principles of Special Education.—Certain general principles apply to the special education of all the categories of defective children listed in Table XXV. These principles are six in number. First, and most obvious, the classes should be small in numbers. From ten to twenty children (depending upon the type of defect) will generally be quite sufficient for one teacher as abnormal children naturally tend to require more individual attention than

do normal ones. Second, specially trained teachers are necessary for dealing with most types of abnormal child. This applies most particularly to the blind. Third, abnormal children should be given as much of the ordinary school curriculum as is possible or suitable. There is no need to modify their education except in so far as their particular abnormality renders it necessary. The short-sighted, for example, were at one time prevented from following all sorts of activities for fear they damaged their eyes. The result was that they left school not only short-sighted but also very ill-educated. It has been found better to give these children a much fuller education to avoid this undesirable state of affairs and, in practice, their eye-sight has not suffered. The fourth principle is that abnormal children should be given vocational training: being taught an occupation by means of which they can earn their living in later life. In this way they are prevented from drifting into occupations which are quite unsuitable for them, and they have knowledge of a trade which offsets, to some extent, the disadvantage under which they labour compared with normal people. Fifthly, arrangements must usually be made for frequent medical attention and supervision of abnormal children to see that their abnormality is not progressing, and also to see if they are benefiting from their special education. Finally, abnormal children of any category may be divided into three grades, according to the degree of their defect. If the defect is slight (short-sightedness, hardness of hearing, dullness not amounting to mental deficiency) the children may be taught in a special class, but at an ordinary school. This gives them the benefits of special education without the disadvantages of being segregated from normal children. Those whose defect is of moderate degree usually require to attend a special school, as they are quite unsuited for competing with normal children in an ordinary school. The special school may, in many instances, be a day school, as it is only their education which presents special problems, and not their ordinary life at home. Where there is a marked defect (stone blindness, marked mental deficiency),

a residential school or institution is generally necessary. These are the general principles underlying special methods of education, and it may be added that most special schools have a tendency, nowadays, to be somewhat of the open-air pattern.

Physically Defective Children.—The three grades of physically defective children are those whose general health is poor but who have not got a specific complaint, those who are crippled to a marked extent and those who have a definite, progressive disease like tuberculosis or rheumatic heart disease. Each grade requires different treatment, as will now be explained.

Day Open-Air Recovery School.—Open-air schools are provided for children whose general health is poor, and whose homes do not present a satisfactory hygienic environment. The full title of an open-air school, as set out at the head of this paragraph, indicates its objects. It is generally a day school, taking the place of the ordinary elementary school. It is, of course, an open-air school and it is a place where children may recover health rather than where they may be cured of specific complaints. The idea of the open-air school arose in connection with the treatment of tuberculosis. It was found that fresh air and sunshine greatly improved this complaint, and so it was thought that the same agencies might benefit other forms of ill-health. There is a definite tendency for modern schools of all types to be of at least semi-open-air character. The aim of the open-air school is to provide nourishment (in the widest sense of the word) and education for temporarily delicate children. Suitable cases are those suffering from undernourishment or from anæmia, those who have had an infectious disease, like measles, and whose complete recovery is retarded by bad hygienic surroundings, and those who, while not suffering from tuberculosis, are weakly and ill-nourished and come from homes where tuberculosis is present.

Type of building.—Fig. 145 shows a plan of an open-air school. There is a main block containing a dining hall,

cloak-rooms and various offices. The class-rooms are built as separate units (island type) along a diagonal line which runs from north-west to south-east. In this way the sun can shine into the class-rooms and one does not cast a shadow upon the next. Each class-room has glazed folding doors on three sides, so that it can be thrown completely open to the air. Only the north wall is of solid brick. Fig. 146 shows a typical island class-room. A suitable shelter is also

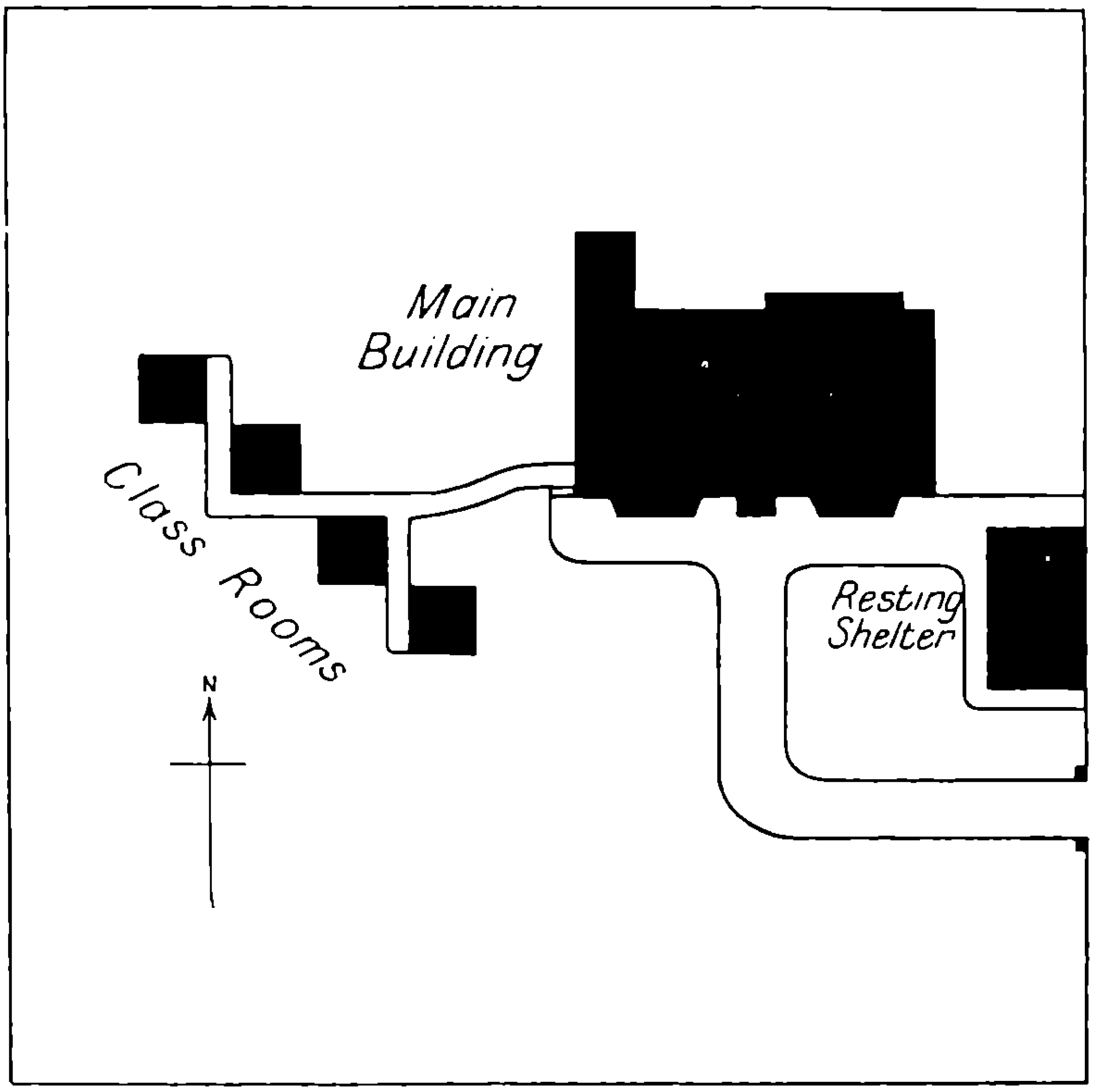


FIG. 145.—Plan of an open-air school.

provided in which the mid-day rest can be taken when the weather does not permit this to be taken entirely in the open air. The resting shelter need be little more than a roof and a screening wall at one side, being open to the air as far as possible (Fig. 147).

General organization. The open-air school must be on the outskirts of a town or in the country to be of real use and it is therefore necessary to have some arrangement for con-

veying children to and from the school. Usually a motor bus picks up children at central points in the town, conveys

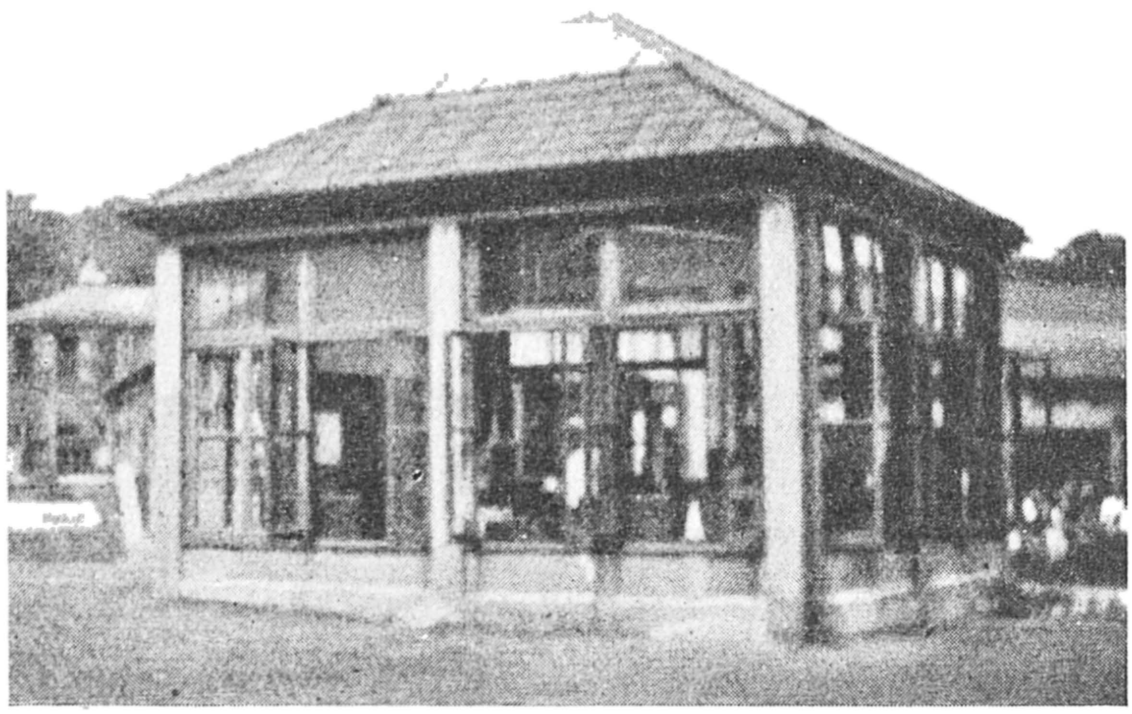


FIG. 146.—An island class-room.

them to the school and collects them again in the evening. As the children spend the whole day at school three meals

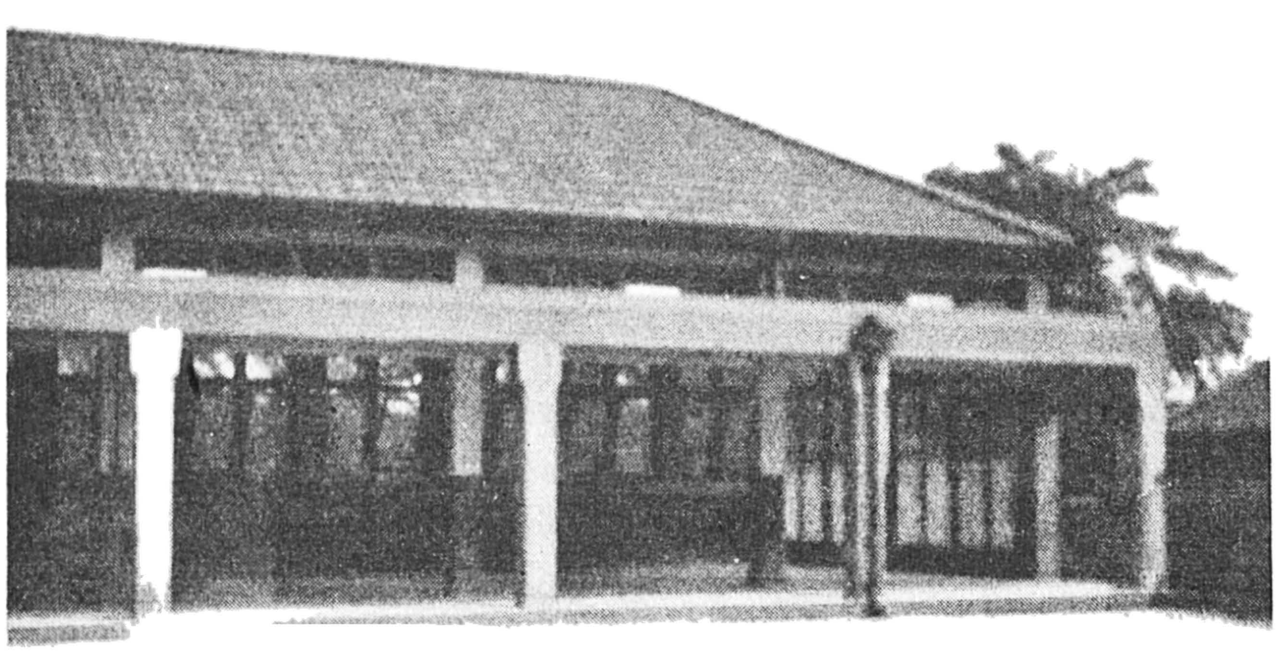


FIG. 147.—A resting shelter.

(breakfast, dinner and tea) have to be provided. The mid-day rest (in the open air whenever possible) is an important

feature of the curriculum, as very many children from poor districts suffer from lack of sleep. Practical work, handwork, physical training and outdoor activities of all kinds bulk largely in the time-table. The staff usually includes a full-time nurse to attend to the hygiene, leaving the teachers free to attend to their proper business, the educational side. The school doctor attends regularly once or twice a week to supervise the health and progress of the children. A child generally remains at an open-air school for about six months.

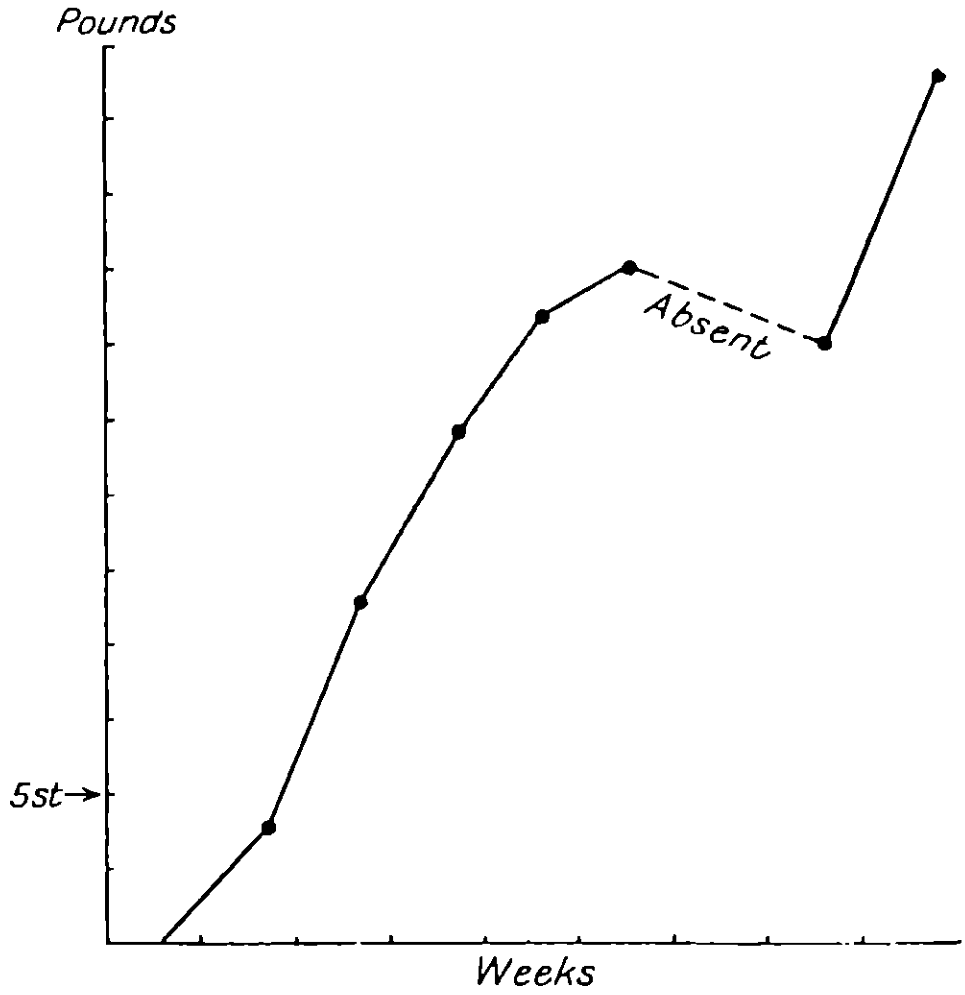


FIG. 148. Increase in weight in a child at an open-air school.

at the end of which time he should be restored to normal health and able to go back to an ordinary elementary school.

Results of open-air schools. During their period at the school children improve markedly in appearance and general health. Their progress may be measured more precisely by recording the weight at frequent intervals. Fig. 148 shows the marked increase in weight which occurred in one child that is typical of the majority. Fig. 149 shows the rate of increase in weight of children at an open-air school compared

with those at an ordinary elementary school. Another measurement that can be conveniently made is the percentage of hæmoglobin (the colouring matter of the red corpuscles) in the blood. Fig. 150 shows such a record. When the children first went to the open-air school they had only 75 per cent. of the normal hæmoglobin content. During their stay at the school the percentage of hæmoglobin increased, fell off during the holidays and again began to rise on their return to school. Results such as these indicate the value of the open-air regime.

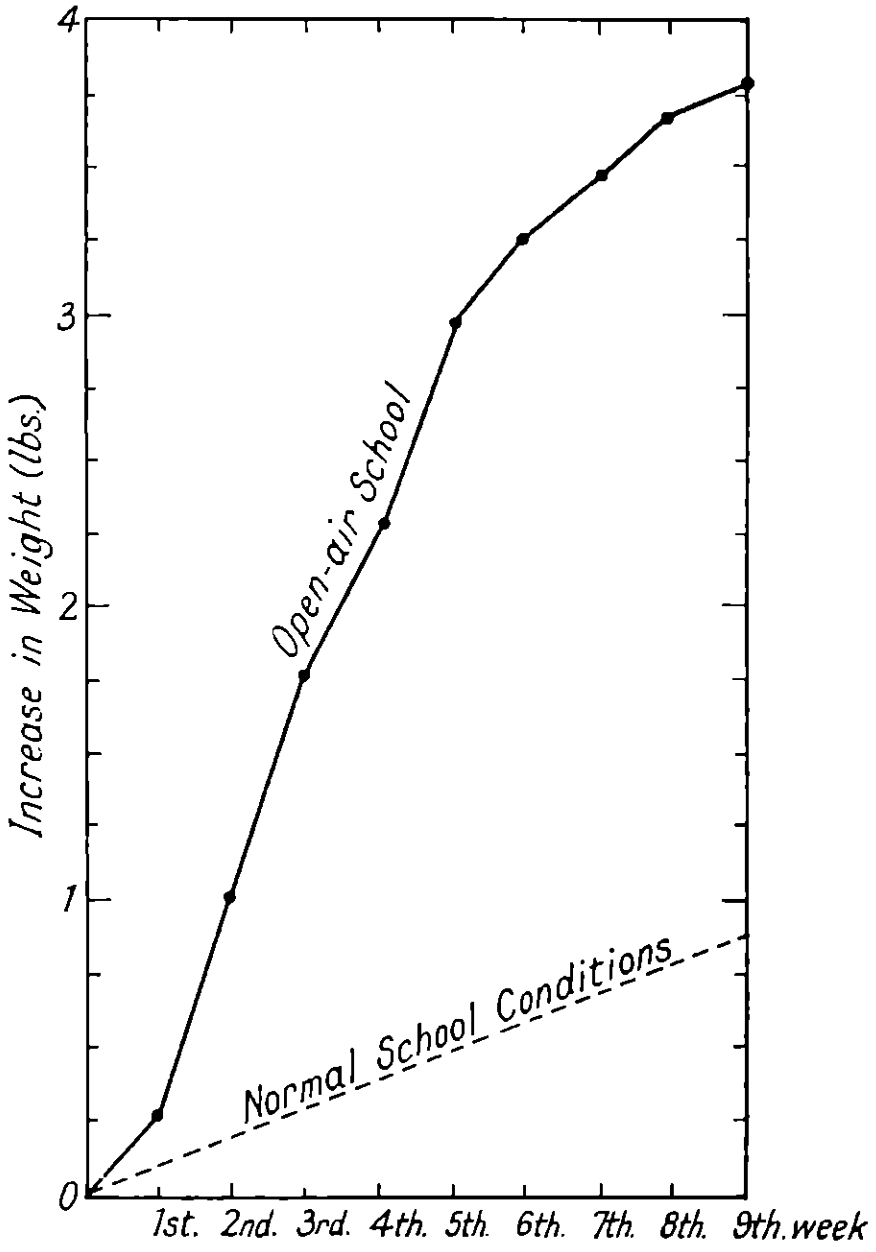


Fig. 149.—Increase in weight of children at an open-air school compared with children at an ordinary elementary school.

School for Physically Defective Children.—The cripple school or school for physically defective children is intended for those who have a crippling deformity so marked as to make them unsuitable for education in an ordinary school. A special school of this type may be residential or, if suitable transport facilities can be arranged, it may be a day school. The curriculum is not fundamentally different from that of an elementary school, but vocational training should be provided for reasons already mentioned. In addition to education a certain amount of medical treatment is given. This most commonly takes the form of massage and remedial exercises. Children remain at a school of this type until

the age of sixteen and, as a result of the facilities they have enjoyed, they have a better chance of benefiting from their education and of going into the world as self-supporting citizens.

Children with Marked Physical Defect.—Children who have a definite disease, needing a considerable amount of treatment, should be placed in institutions which are hospitals rather than schools. Examples of these have already been mentioned in the chapter upon tuberculosis and rheumatism. No more need be said about them here.

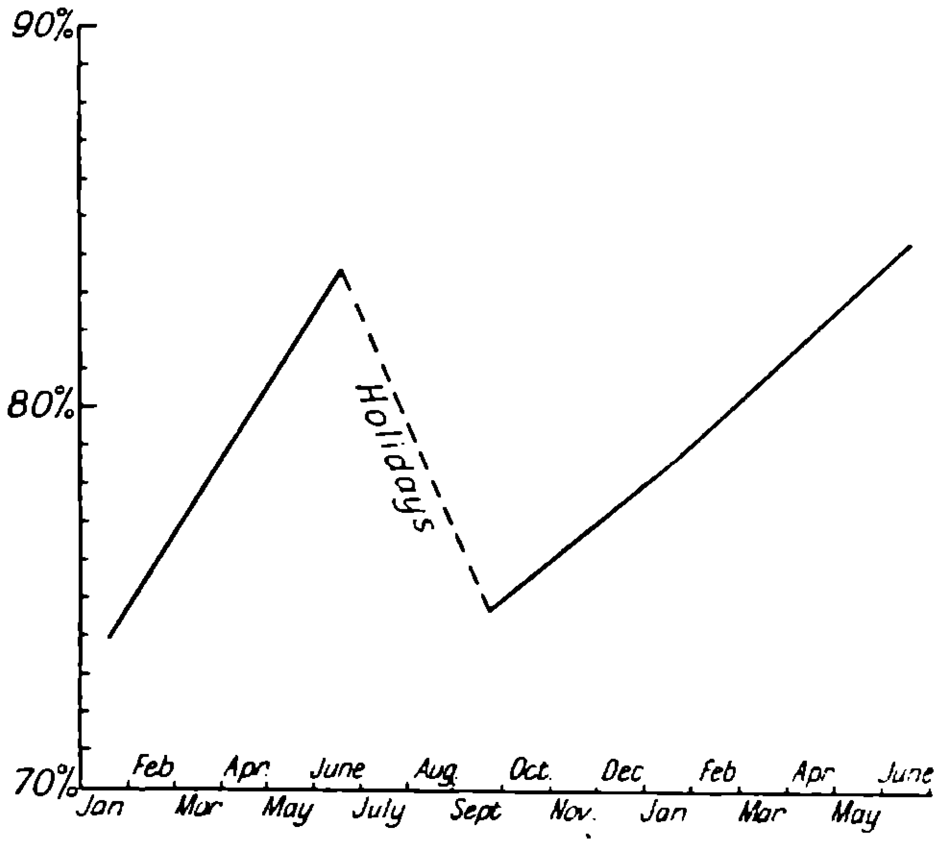


FIG. 150.—Increase of hæmoglobin in the blood of children attending an open-air school.

Mentally Defective Children.—There is a considerable amount of confusion about the use of the term mentally defective. Some people reserve the term for ineducable subnormal children who are, of course, outside the scope of any educational system. To those children who, although subnormal, are nevertheless educable to some extent, they apply the term retarded. In England, two types of mentally defective are known to the law: those who are defective within the meaning of the Education Act and those who are defective within the meaning of the

Mental Deficiency Acts. The Education Act is concerned only with lack of intelligence: educational deficiency. A child would be defective in this sense if he failed to obtain a satisfactory intelligence quotient when submitted to suitable tests and might be certified under the Act if he were incapable (by reason of mental defect) of benefiting from the education given in a normal elementary school, provided he was capable of benefiting from education in a suitable special school. In other words, he must be educable although subnormal. The Mental Deficiency Acts are concerned with social incapacity rather than with educational deficiency, and they apply not only to children but to persons of any age. Some educational defectives may manage, after leaving school, to fend for themselves quite satisfactorily in a humble sphere of life, and are not then defective from the point of view of the Mental Deficiency Acts. Others, although not unduly backward educationally, may lack the ability to look after themselves, to lay out their wages to buy food and clothing, and thus may need to be certified under the Mental Deficiency Acts. It is important to realize that there is no clear-cut division between children who are normal and children who are mentally defective. The normal blends gradually with the subnormal and our classifications are only made as matters of convenience. It is useful to recognize three grades of mental subnormality.

Dull and backward children.—Dull and backward children need to be placed in a special class at an ordinary school. The common division of a class into A, B and C divisions is a recognition of this need. Complete segregation would be undesirable, but for some lessons the duller children need to go at a slower pace.

Educationally defective children.—The children in this group are those who can benefit from education in a special school although they cannot make satisfactory progress in an elementary school. They attend the mentally defective school (a bad term), which is usually a day school, as, apart from their educational peculiarities, they are not unfit

to mingle with people in the normal world. The school curriculum needs to be modified for these children to some extent, and a large proportion of the time (up to 50 per cent. of the time-table) is devoted to practical work of a vocational character. The children remain at school until the age of sixteen, and the best ones amongst them may reach standard four grade by that age. They are medically examined at least once a year and their mental as well as bodily development is noted.

Low grade defectives.—Subnormal children who prove to be ineducable even in a special school are placed in residential institutions where they can have care and supervision and can, perhaps, be taught some simple occupation of a routine character.

CHAPTER 33

THE SCHOOL MEDICAL SERVICE AND OTHER AGENCIES FOR CHILD HEALTH

The School Medical Service was inaugurated by the Education (Administrative Provisions) Act of 1907. This Act laid upon Local Education Authorities the duty of having school children medically examined. These inspections, though no longer the sole work of the Service, still constitute its most important task and so will be considered first.

Medical Inspection.—Children must be inspected at least three times during their elementary school life: in the twelve months following their first admission to school (entrants), in the twelve months following the eighth birthday (intermediates) and in the twelve months following the twelfth birthday (leavers). Children in special schools are inspected annually. Medical inspection must be carried out during normal school hours, and it is desirable that one of the parents (preferably the mother) should be present. The doctor may want to know something of the child's history or that of his family, or he may want to give instructions regarding some defect in the child or some treatment that he recommends. For these reasons it is customary to notify parents of the date, time and place of the examination of their child. Printed cards are usually given or sent to parents naming any ailment which the doctor has discovered in the child and detailing the treatment. They may obtain treatment from their own doctor, from a hospital or from the school clinic.

Table XXVI shows the type of form upon which is kept a record of the medical inspections of a child. Parts of

TABLE XXVI.—Medical Record Form

I. Name ....Date of Birth.................

Address ....School

II. Personal History—

(*a*) *Previous Illnesses of Child* (*before admission*).

Measles.	Whooping Cough.	Chickenpox	Scarlet Fever.	Diphtheria	Other Illnesses.

(*b*) *Family Medical History* (*if exceptional*).

•	I	II	III	IV		I	II	III	IV
1. Date of Inspection. 2. Standard and Regularity of Attendance. 3. Age of Child. 4. Clothing and Foot Gear. (III. *General Conditions.*) 5. Height. 6. Weight. 7. Nutrition. 8. Cleanliness and condition of skin Head. Body. (IV. *Special Condiditions.*) 9. Teeth. 10. Nose and Throat. Tonsils. Adenoids. Submaxillary and Cervical Glands. 11. External Eye Disease. 12. Vision. R. L.					13. Ear Disease. 14. Hearing. 15. Speech. 16. Mental Condition. (V. *Disease or Deformity.*) 17. Heart and Circulation. 18. Lungs. 19. Nervous System. 20. Tuberculosis. 21. Rickets. 22. Deformities, Spinal Disease, etc. 23. Infectious or contagious disease. 24. Other disease or defect. Medical Officer's initials.				

General Observations.

Directions to Parent or Teacher.

this form are filled in by the teacher and the school nurse before the doctor's visit. The first section deals with particulars for office use, such as the child's name and address and date of birth. The second section deals with the previous history of the child, a note being made of the occurrence of the more important infectious diseases. More room is, of course, left for writing than appears in the Table. A note is made of the family history if this appears to have any bearing upon the child's health. It is important to know, for example, if there is a family history of such a disease as tuberculosis. The remaining matters dealt with on the form require investigation at each medical examination and spaces are provided for the three usual inspections with room for one or two extra ones in case these are made. The standard of regularity of attendance gives some indication of the child's usual health. Grossly irregular attendance generally indicates bad health. The state of the clothing and footwear is also of some importance. A child who is ill-clad and badly shod is very likely to catch cold in winter and to suffer from influenza and other winter ailments. The third section of the form concerns the general condition of nutrition and cleanliness: it represents an assessment of the hygienic state of the child. Section four relates to some particular aspects of hygiene such as the state of the teeth, the ear and the eye. Finally, enquiry is made into the state of certain of the important physiological systems and into the presence or absence of some important diseases. The doctor cannot spend much time on each child but the examination serves to distinguish the reasonably healthy from the ailing. These latter may then be submitted to a more leisurely and detailed examination, probably at the school clinic. At the foot of the form a record is made of any instructions which the doctor may give to the teacher or parent.

Results of Medical Inspection.—During the thirty years which have passed since the passing of the Act establishing school medical inspection certain results have accrued. In the first place, valuable statistics have been

collected which indicate weaknesses in the health of the school population and so direct the spending of public money into suitable channels for the eradication of these weaknesses. Physical defects of children are detected earlier than formerly, when there is more chance of correcting them successfully. This means that children lose less time from school. The leaving child is physically better than his predecessor of thirty years ago. He is taller, heavier, better nourished and more free from preventable defects like uncorrected short sight and untreated adenoids. The leavers of to-day therefore are more likely to become useful, self-supporting citizens.

The School Medical Officer. In most parts of the country the Chief School Medical Officer is also the Medical Officer of Health. In some places, however, the two offices are held by different people. In either case the Chief School Medical Officer is responsible for the general supervision of the health of all school children in his district. He also advises the Local Education Authority on such matters as the planning of school buildings, the organization of special schools, school sanitation and equipment and the like. The assistant medical officers visit the schools and conduct the routine examinations. They also give treatment at the school clinics and make psychological examinations in connection with mental deficiency.

The School Dental Officer. School dentists do the same kind of work as the medical officers, but limited, of course, to the care of the teeth.

The School Nurse. The school nurse assists the doctor and dentist at examinations and with treatment at the clinic. She also visits the schools by herself and, with the assistance of the teachers, picks out ailing or undernourished children to send before the doctor. In those cases where it appears necessary, the nurse examines children to see whether or not they are verminous. At special schools a nurse usually attends full time. The school nurse also visits the homes of children who have been

excluded from school for any reason, in order to see how they are progressing and whether they are receiving proper treatment. It is advantageous if the nurse is also the district health visitor, for then she will be familiar with the children and their family circumstances before they reach school age.

The Teacher's Part in School Medical Work.—As the teacher is much more in contact with the children than the officers of the School Medical Service, it falls to him to notice defects and ailments in the first place. Hence it is desirable for teachers to have some knowledge of the signs of malnutrition and the common diseases of children. The teacher has also to deal with matters of hygiene and cleanliness, influencing both children and their parents in these things. It may be the duty of the teacher to make regular records of the weight and height of his pupils, for these form (as has already been mentioned) valuable indications of a child's physical progress. Teachers also have to assist at medical inspections in many cases.

The School Clinic.—The Act of 1907, to which reference has already been made, did not make any provision for the treatment of the defects which might be revealed by medical inspection. This came later with the Education Acts of 1918 and 1921, under which school clinics were established. The clinic deals with minor complaints, such as sight-testing, some skin diseases, and adenoids and diseased tonsils. Dental treatment is also provided. An arrangement is usually made with a local hospital for the treatment of more serious disorders. The time which a child spends at the clinic and in travelling to and from the clinic counts as school attendance for the purpose of obtaining grants by the Local Authority. Some suitable system of registering these visits has to be adopted in each district.

The Ante-Natal Clinic.—From what has been said, it will be clear that considerable attention has been paid to the health of the school child for many years past. The

modern tendency, in all countries, is for the Government to interfere with its citizens earlier and earlier in their lives, and attention is nowadays directed to the child even before birth. The ante-natal clinic supervises the health of the expectant mother and the unborn child, endeavouring to correct abnormalities and ailments of pregnancy in order to secure normal birth, so that the child may, at least, make a right beginning of life. The clinic is not in any sense an educational centre, although many prospective mothers are extremely ignorant of how to care for and bring up a baby.

Post-Natal Work.—After birth two agencies operate to supervise the welfare of the infant. Health visitors (who may also be school nurses) visit the homes and advise the parents in the care of their children. The Maternity and Child Welfare Centre is a sort of post-natal clinic where mothers may receive advice about the feeding and clothing of the baby, and treatment for simple complaints. Voluntary organizations often assist at these centres by providing clothing for the very poor and by showing the ignorant how to make clothes. Sometimes talks and discussions are arranged about general matters of infant welfare.

The Day Nursery.—The day nursery or crèche provides for the slightly older child who may now be considered apart from its mother. The nursery undertakes to mind children while their mothers are, perhaps, out at work. The nursery is not in any sense a school, and does not attempt to teach the children.

The Nursery School.—At the age of three a child becomes eligible to attend the nursery school. Here more than mere minding is carried on, the child being trained in simple habits of hygiene and tidiness. A proper midday meal may be provided and also morning milk and an afternoon rest. These schools are generally run upon open-air lines. At the age of five, after the nursery school, the child reaches ordinary elementary school age and comes under the supervision of the School Medical Service.

School for Mothers.—A rather more ambitious scheme to secure child health is the school for mothers. This may be run in conjunction with a maternity and child welfare centre. Here regular courses of lectures and demonstrations may be given in all that pertains to mothercraft and the upbringing of children. This is particularly useful if it follows a more elementary course given to senior girls in the schools.

Child Guidance Clinic.—Mention must be made of a type of clinic which exists in some centres for dealing with "difficult children" who present "behaviour problems." At the child guidance clinic psychiatrists, psychologists and specially trained social workers investigate the mentality, environment and history of these children, and endeavour to remove the causes of their abnormal behaviour, and make recommendations for their future treatment.

PART VI

HYGIENE AND EDUCATION

CHAPTER 31

HEREDITY

In previous chapters we have been concerned with factors, external to the child himself, which influence his health and education. Our concern has been, in fact, with his environment. Each child, however, is born with certain potentialities which he inherits from his ancestors and which constitute his hereditary make-up. The adult who at last eventuates is the product of the inter-action of environment and heredity.

Significance of Heredity.—Heredity simply means that like begets like: elephants have baby elephants and human beings have young humans. We are apt to accept these constantly recurring phenomena without realizing how amazing they are. Since all living things begin life as a single cell it is obvious that parental characteristics are transmitted to the offspring through the ovum and spermatozoon (Chapter 11). The reproductive cells are set apart early in life, a considerable time before birth, and so are not affected by the environment of the individual to any great extent. If a man loses an eye in an accident he may nevertheless become the father of normal, two-eyed children, as such an environmental catastrophe does not affect his reproductive cells. Some kinds of poisoning (such as chronic alcoholism) can, however, affect the offspring by the poison circulating in the blood stream and so reaching the reproductive cells as well as all the others in the body.

Dominant and Recessive Characters.—Every child has two parents and so inherits two groups of hereditary characteristics. If the parents both have black skins the child, too, will be black. If both have fair hair or blue eyes the child will have the same features. When the parents are dissimilar the inheritable characteristics may be of conflicting nature, and in some particulars the child must take after one parent rather than the other. When black and white marry the children are brown, the blackness of the one parent being diluted, as it were, by the white-

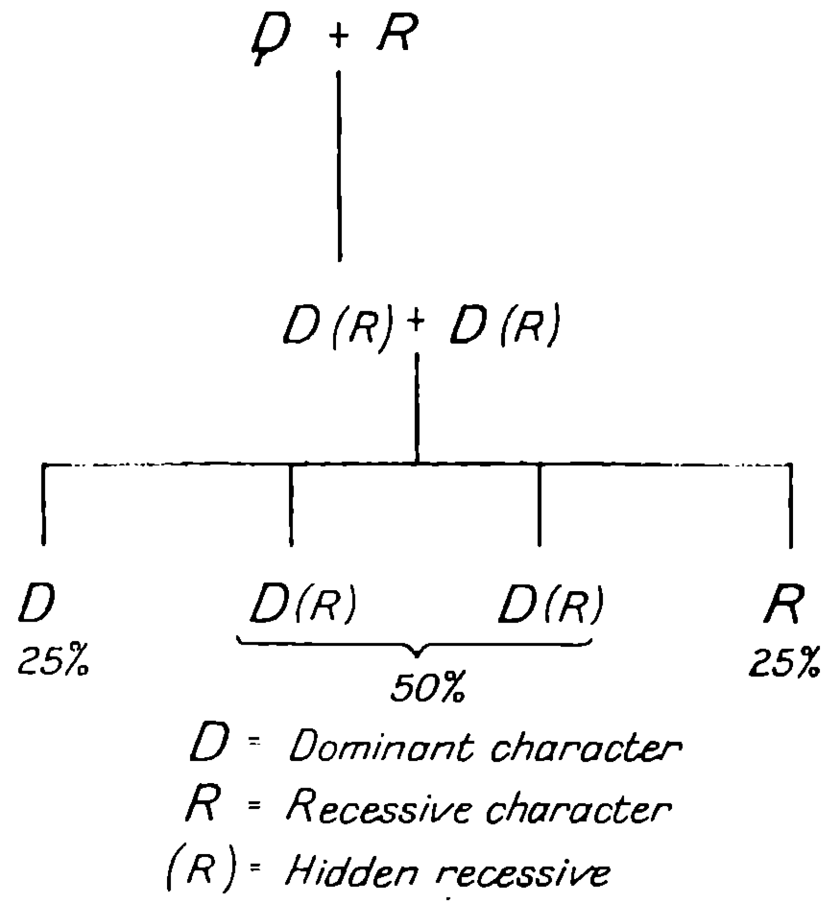


FIG. 151.—Dominant and recessive characters in inheritance.

ness of the other. If one parent has brown eyes and the other blue, mixing cannot occur and the child usually inherits the brown eyes. Characteristics such as this, which tend to take precedence when a choice has to be made, are called dominant characters. Recessive characters are those which are suppressed. Fig. 151 shows the sort of thing which occurs. Although the dominant character is apparent in the offspring the recessive character (hidden) may be transmitted and appear in future generations.

Heredity and Education.—The colour of a child's eyes is not important from the point of view of its education,

but some other hereditary characters are very important indeed. Some kinds of physical defect or abnormality are inherited and cannot be remedied although they profoundly modify the life of the individual. Mental dullness and, sometimes, mental deficiency may also be of an hereditary nature. In fact, poor stock tends to give rise to poor stock, and this cannot be altered by training or education. The matter is not sufficiently appreciated at the present time, for schemes of special care and special education are elaborated at considerable cost in spite of the fact that only one generation will be affected, the problem arising anew in each successive generation. It costs about nine times as much to care for a mentally defective child, for example, as for a normal child in an elementary school. Poor stock (shiftless people, incapable of planning ahead) tends to overbreed, and so an increasing strain is placed upon the resources of the better members of the community as they have more and more passengers to carry through life.

CHAPTER 35

THE TEACHING OF HYGIENE

A KNOWLEDGE of hygiene is useful to a teacher in two ways. Having charge of children, it is clearly desirable to know something of the way in which their bodies work, the conditions which are necessary for the maintenance of normal health and the early signs of the commoner ailments. In addition to this, however, the teacher has to instruct children in matters relating to health ; not necessarily by formal lessons upon hygiene but, at least, indirectly by example and precept. The teacher's knowledge of hygiene must be of two sorts. First, it is necessary to have some conception of the biological and physiological principles underlying the working of the body. Second, the practical application of these principles to matters of school life must be understood.

Principles of Hygiene Teaching.—Training in proper habits can hardly begin too early in life, but very young children should not be given definite instruction in matters relating to health. Good habits should rather be inculcated by example and by supervision. Junior children may be given definite instruction of a practical nature but should not be burdened by theory. Children over Standard V may benefit from purely theoretical instruction in selected aspects of hygiene.

Methods of Hygiene Teaching.—The teacher should exercise general supervision over the health of the children. Those who have spectacles should be made to wear them on the proper occasions. All the children should be made to adopt reasonable postures for sitting and standing. Cleanliness of body and clothing should be encouraged. The

teeth, the hair and the finger-nails should be cared for. The teacher should also be on the watch for signs of eye-strain, deafness, undernourishment and disease. When practicable, it is good to make regular records of the height and weight of children for reasons explained in an earlier chapter. Some of these matters may receive specific attention. Thus the cleanliness of hands may be ascertained before some lesson, such as drawing, for which cleanliness is more than ordinarily desirable. The state of hats and coats may be discovered by a member of the staff inspecting the cloak-rooms at regular intervals.

The example of the teacher in matters of hygiene is also important, and it is as well to be more than usually fussy about such things as ventilation and general tidiness of the class-room and school. Needless to say, the personal appearance of the teacher should be beyond reproach. It is often useful to appoint monitors who may be made responsible for opening windows, for supervising the use of wash basins and other, similar, matters. This not only relieves the teacher but encourages children to compete for these positions of hygienic responsibility by themselves achieving a satisfactory standard.

Actual lessons upon hygiene may take a practical form, such as toothbrush drill, or may be of a theoretical character, dealing with some of the topics discussed in the earlier parts of this book.

Hygiene and Other Subjects.—When hygiene does not actually figure in the time-table it may still be brought into lessons upon other subjects. Biology and nature study lend themselves to excursions from animals and plants into human physiology. Domestic economy and sewing give the opportunity for making reference to dietetics and the hygiene of clothing respectively. Even such subjects as history and geography are related to hygiene as the course of human progress has been profoundly modified by the spread of disease and by the possibility of its conquest, while the mode of life and political importance of the different nations are very intimately connected with the climates of their coun-

tries, the crops which they can grow and the parasites which dwell among them.

Temperance Teaching.—A particular aspect of hygiene teaching is instruction concerning the use and abuse of alcoholic beverages. This was much more important in the past when intemperance was widespread. Considerable tact is necessary in dealing with this subject as, although most parents are not drunkards, they may not be strict teetotallers. They will, not unnaturally, be offended if their children express exaggerated opinions which they claim to have acquired from the teacher. Nevertheless, fear of giving offence should not deter anyone from telling the truth. A lesson upon temperance is best given by the ordinary class teacher and not by a visiting lecturer (as is frequently the case). The special lecturer often tends to be fanatical and the address loses much of its value if it appears to be obvious propaganda. The class teacher should try to avoid giving an isolated lesson upon alcohol : it should take its place naturally in a series of other lessons, say, upon food and drink or upon the value of "moderation in all things." There is no doubt that total abstinence from all alcoholic beverages is ideally desirable and there is no physiological justification for their use, indeed, there are many good reasons for excluding alcohol from the healthy body (Chapter 14). In practice, however, the advocacy of temperance is more likely to meet with success than that of total abstinence.

There are three approaches to the subject. A description of the physiological effects of alcohol (as given in Chapter 14), suitably modified for children, may have considerable value and certainly avoids controversial issues. The study of tables of mortality and of expectation of life forms a second statistical approach. Such tables reveal that teetotallers tend on the whole to live longer than others and that, at any given age, they have a somewhat greater expectation of life. These facts are well known to insurance companies and generally appeal to children. It should be borne in mind, however, that the accurate interpretation of statistics

requires knowledge and experience so that the statistical approach to temperance teaching leads at times to controversy. The social effects of alcohol may also be pointed out, but here one enters into a field which is largely a matter of opinion and not of fact. Undoubtedly drunkenness is likely to lead to loss of employment (even to crime) and resulting misery and ill health in the drunkard's family. Alcoholic beverages are relatively dear when compared with other, less harmful, pleasures. An enormous amount of money is spent each year in the purchase of alcohol and this money is, of course, diverted from buying food, clothing and other things.

Sex Teaching.—Opinions differ about the need for, and value of, instruction about sex. Most people realize that some instruction is desirable as knowledge is inevitable, and should preferably be accurate and authoritative. The matter is best dealt with by the parent, if sufficiently intelligent and informed, but the duty may devolve upon a teacher in some circumstances. It is bad for a specialist, such as a doctor or a clergyman, to give a special talk upon the subject, as this inevitably places it in wrong perspective as in the case of a temperance talk given by a special lecturer.

It is a great mistake to flounder into a maze of falsehoods and evasions when dealing with children. If their questions are answered simply and truthfully, without going beyond the actual scope of the question asked, much trouble and confusion may be avoided. If a child keeps pet animals and is allowed to breed with them the whole problem is usually solved as the knowledge gained in this way is gradually and unconsciously applied to human beings. As regards specific instruction, all children accept the emergence of a plant from a seed or a bird from an egg, and the simplest explanation of the origin of young animals and human babies is that in these cases the egg hatches within the mother and the finished creature is born much as an egg is laid. This explanation not only has the advantage of being within a child's comprehension but is, in addition,

phylogenetically true. It should be understood that the question of sex is not, in a child's mind, associated with the same complex pattern of emotions and sentiments as in the case of an adult. A brief explanation, given in a casual manner without ponderous mystery, generally suffices. Fertilization may also be explained by reference to plants.

Some people consider it wise to instruct girls about menstruation before this actually occurs. This may be desirable in the case of a child who has gained partial knowledge through association with older children. In many cases, however, the explanation is better deferred until the actual commencement of menstruation. It is certainly wrong to offer no explanation at all, leaving the child to be surprised and probably frightened. Care should be taken to make it quite clear that the process is normal and to avoid representing it as a recurrent phase of ill-health. In the majority of cases menstruation should not interrupt the ordinary life of the individual to any significant extent.

The reader may supplement the information about the teaching of hygiene, given in this chapter, by reference to the Board of Education "Handbook of Suggestions on Health Education," published by His Majesty's Stationery Office at sixpence.

CHAPTER 36

THE LAW RELATING TO SCHOOL CHILDREN

There are many Acts of Parliament relating to children and education. The more important ones which have some bearing upon health will be briefly summarized in this chapter. Commonly, when a new law is introduced, it is permissive in character: it permits a Local Authority to do something without compelling it. The more progressive Authorities make use of this permission and, if it is found (as a result of their experience) that the Act is workable and useful, a second law generally follows, compulsive in character, making the innovation obligatory all over the country. Acts of Parliament usually indicate only the broad outlines of what is intended. The details are supplied in Orders and Regulations issued by Ministers of the Crown under the Authority of the Act. Such Orders and Regulations have the force of law.

Elementary Education (Blind and Deaf Children) Act, 1893.—Before the passing of this Act, blind and dea children often did not receive satisfactory education. They could not participate properly in the work of the ordinary elementary school and, in the case of the blind, the parents could plead that the child could not easily attend school at all. This Act compelled parents to see that these abnormal children received efficient elementary education and obliged Local Education Authorities to provide special classes or schools. The education of these children was made compulsory until the age of sixteen.

Elementary Education (Defective and Epileptic Children) Act, 1899.—This was a permissive Act saying that

Local Education Authorities might provide special education for these Children in the form of a special class or a special school. A doctor's certificate was necessary to define the suitable children, and their education was compulsory until the age of sixteen.

Education (Provision of Meals) Act, 1906.—This was again a permissive Act allowing Local Authorities to provide, or to assist in providing, school meals. For this purpose they might utilize a sum of money equal to a halfpenny rate in their district.

Education (Administrative Provisions) Act, 1907.—This Act established the medical inspection of children in elementary schools. It was compulsive in this respect, but permissive as regards the provision of treatment.

Children Act, 1908.—This Act is often known as the Children's Charter. It deals with various aspects of child welfare such as the prohibition of juvenile smoking and the prevention of cruelty to children. It concerns school hygiene inasmuch as it deals with the cleansing of verminous children, but more extensive powers in this direction were given by an amendment Act of 1932.

Mental Deficiency Act, 1913.—Under this Act Local Authorities must ascertain which are the mental defectives in their area and must provide proper supervision for them. Certified defectives can be sent to an institution and may be detained there for life.

Elementary Education (Defective and Epileptic Children) Act, 1914.—The corresponding Act of 1899 was permissive in its provisions. The Act of 1914 was compulsive and obliged Local Authorities to make special provision for these defective children.

Education (Provision of Meals) Act, 1914.—This extended the earlier Act of 1906 by removing the financial limit already referred to, and by permitting the provision of meals during holidays and on other days when the

schools are not normally open. It had been seen that the value of school feeding was diminished if a child had to pass through the holidays without an adequate diet.

Education Act, 1918.—This Act extended the powers of Local Education Authorities with respect to medical inspection and physical education. Most of the provisions of the Act were incorporated in the one described next.

Education Act, 1921.—This co-ordinated and codified the previous Acts, repealing some of them but re-enacting certain of the repealed provisions. Many of the powers already mentioned are now exercised under this Act. The most important measures contained in the Act are as follows: Local Education Authorities must provide medical inspection for secondary and continuation schools as well as for elementary schools. Treatment must also be provided for elementary schools and *may* be provided for the others. Parents must pay for treatment except in necessitous cases. Nursery schools, holiday camps, physical training centres and the like may be maintained or assisted.

Mental Deficiency Act, 1927.—This altered the corresponding Act of 1913 by giving a slightly different definition of mental deficiency.

Children and Young Persons Act, 1933.—This Act placed upon Local Education Authorities the duty of providing remand homes for children and young persons who had been before the magistrates.

The effect of the legislation relating to child health and welfare may be summarized in the words of Dr. Stockwell, the School Medical Officer of Leeds: "All these various Acts have been framed to ensure that the health and well-being of the children of the country should be safeguarded, and to provide :—

"(1) That every child shall periodically come under medical and dental supervision.

"(2) That for every sick or defective child, skilled medical treatment should be available, either by local Education Authorities or otherwise.

"(3) That every child found malnourished shall be fed, and that every child found verminous shall be cleansed.

"(4) That every child should be taught in healthy surroundings.

(5) That every child shall have opportunities for supervised physical training.

"(6) That no child of school age shall be employed for profit except under supervision.

"(7) That every defective child shall be educated in a school where his disabilities are specially provided for in the curriculum, environment or equipment."

VOCABULARY OF TECHNICAL TERMS

Accommodation. The adjustment of the eye for focusing near objects.

Adenoids. A soft, fleshy mass which sometimes grows at the back of the nose and interferes with breathing. It may also cause deafness.

Adrenal Glands. Endocrine organs, situated one on top of each kidney. (Latin: *ad*, near to; *ren*, the kidney.)

Adrenalin. The hormone produced by the adrenal glands.

Air Cell. A space in the lungs containing air.

Alimentary Canal. The muscular tube along which the food passes, from the mouth to the anus, during digestion.

Alkali. A substance, such as caustic soda or ammonia, which can neutralize an acid. Strong alkalies are corrosive.

Amœba. One of the simplest animals. Consists of a single cell.

Anæmia. A complaint in which the blood is of poor quality, containing insufficiency of hæmoglobin or red corpuscles or both.

Anatomy. The science which treats of the structure of the body.

Ante-natal Clinic. A place for supervising the welfare of expectant mothers and unborn children. (Latin, before birth.)

Antibacterial Substance. A chemical substance manufactured by the body to destroy germs. (Greek, *anti* = against.)

Antibody. Any substance produced by the body to destroy germs or their toxins.

Antiseptic. A chemical agent which prevents the growth of germs.

Antitoxin. A substance produced by the body to neutralize a germ-poison.

Anus. The lower opening of the alimentary canal.

Aorta. The principal artery of the body.

Aqueous Humor. The watery liquid contained in the front part of the eyeball.

Artery. Any blood vessel carrying blood away from the heart.
Aspiration. The action of the wind in drawing air out of a room.
Astigmatism. A defect of vision caused by unequal curvature of the eyeball or the lens.
Auditory. Pertaining to hearing.
Auricles. The upper chambers of the heart, receiving blood from veins.

Bacterium (pl. *-ia*). See *germ*.
Beri-beri. An Eastern disease caused by lack of vitamin B.
Bicuspid. A tooth with two points or cusps. See *premolar*.
Bile. The liquid produced by the liver.
Blepharitis. Inflammation of the eyelids.
Braille. The print used by the blind (Louis Braille, inventor).
Bronchiole. One of the smallest air passages in the lungs.
Bronchus (pl. *-i*). One of the larger air passages into the lungs.

Caffeine. A stimulant contained in coffee and tea. See *theine*.
Calcium. Metallic element contained in lime.
Calorie. A measure of heat. One large calorie is the amount of heat required to raise a litre of water one degree centigrade.
Canine Tooth. A pointed, fang-like tooth. (Latin, *canis* = a dog.)
Capillary. A minute blood vessel. (Latin, *capillus* = a hair.)
Capsule of a Joint. The collection of ligaments binding together the bones which form the joint.
Carbohydrates. The sugary and starchy foods.
Carbon Dioxide. A waste product given off by living cells in the form of a gas.
Cardiac. Pertaining to the heart. (Greek, *kardia* = the heart.)
Caries. Decay of the teeth.
Cartilage. Gristle.
Cataract. A disease of the eye in which the lens loses its transparency.
Cell. A unit mass of protoplasm.
Cerebellum. One of the nerve centres forming the brain.
Cerebrum. The principal nerve centre of the brain.
Chorea. Rheumatism of the brain: St. Vitus' Dance.
Choroid. The middle coat of the eyeball, containing black pigment.

Chyme. Lymph flowing from the small intestine and containing fat.

Ciliary Body. A ring of muscle in the eyeball controlling the focussing of the lens.

Coccyx. A small bone at the base of the vertebral column, corresponding to the tail of lower animals.

Cochlea. Spiral cavity of the internal ear. (Latin, a snail.)

Concave Lens. A lens which is thinner in the middle than at the edge.

Concussion. Loss of consciousness due to a blow on the head : stunning.

Conjunctiva. The transparent membrane in front of the eye.

Conjunctivitis. Inflammation of the conjunctiva.

Convection. The movement of masses of air at different temperatures.

Convex Lens. A lens which is thicker in the middle than at the edge.

Cornea. The transparent part of the eyeball immediately beneath the conjunctiva. (Latin, horny.)

Corpuscle. A blood cell. (Latin, a little body.)

Cranium. The upper part of the skull, containing the brain.

Cretin. A dwarf, usually of low mentality, suffering from lack of thyroid hormone.

Crypt. A tubular depression in the small intestine, lined by cells which produce the intestinal digestive juice.

Dentine. The hard material of which teeth are made.

Dermis. The true skin lying beneath the false, outer skin or epidermis.

Diabetes. A disease in which sugar accumulates in the blood owing to lack of insulin ; which is necessary for the proper utilization of sugar by the body.

Diaphragm. A dome-shaped muscle separating the chest from the abdominal cavity.

Diffusion. The mixing of gases in the atmosphere.

Duct. A tube or passage, generally conveying a liquid from a gland to some place where it is required.

Enamel. The hard outer coating of the teeth.

Endocrine Organ. A mass of cells producing a chemical substance (called a hormone) which circulates in the blood and affects the behaviour of other body cells. (Greek, to separate within.)

Epidermis. The outer layer of the skin. (Greek, above the skin.)

Epiglottis. A piece of cartilage at the upper end of the larynx, above the region known as the glottis. (Greek, *epi* = above.)

Eustachian Tube. Tube connecting the middle ear with the back of the nose. (After the anatomist, Eustachius.)

Excretion. The action of a cell in getting rid of a waste product. Also the waste product itself. (Latin, *ex* and *cernere*, to sift.)

Ferment. An organic substance which alters the nature of food in the alimentary canal during the process of digestion.

Gall. See *bile*.

Ganglion (pl. *-ia*). A collection of nerve cells; a small nerve centre.

Germ. A minute living organism, many of them causing disease in man.

Gland. A collection of cells producing a liquid. Except a lymphatic gland, which is badly named.

Glycogen. A form of carbohydrate stored in the liver and used by the muscles. It is formed from the food which is eaten.

Grey Matter. The parts of the brain and spinal cord where the cell bodies of neurones are congregated, giving rise to a grey appearance.

Gullet. The food passage from the mouth to the stomach.

Hæmoglobin. The colouring matter of the red corpuscles of the blood.

Hair Follicle. A depression or socket in the skin, containing a hair.

Hereditary. Inherited from ancestors.

Heredity. Inheritance: the tendency of like to beget like.

Hip Girdle. The ring of bone joining the legs to the trunk.

Hormone. The secretion of an endocrine organ. (Greek, to arouse to activity.)

Hypermetropia. Long sight.

Immunity. Resistance, natural or artificial, to an infectious disease.

Immunization. The process of rendering a person artificially immune to an infectious disease.

Incisor. One of the front, biting teeth. (Latin, a cutter.)

Inhibition. Restraint of the reflex activity of a lower by a higher nerve centre.

Inoculation. An injection of some material designed to confer immunity.

Insulin. The hormone of the pancreas. (Latin, *insula*, an island, because the cells producing the hormone are collected in islands among the other cells of the pancreas.)

Intervertebral Disc. A disc of cartilage between the bodies of two adjacent vertebræ.

Intervertebral Ligaments. Fibrous bands connecting the vertebræ with one another.

Intestines. The bowels. The parts of the alimentary canal which follow the stomach.

Iris. The coloured part of the eye.

Lachrymal Gland. The tear gland. (Latin, *lacrima* = a tear.)

Lacteal. A lymphatic channel in the small intestine conveying chyme.

Larynx. The voice box : the upper part of the windpipe.

Ligament. A fibrous band connecting two bones with one another.

Lymph. A clear, watery liquid which filters off from the blood as it flows through the capillaries.

Lymphatic Channel. A small channel containing lymph.

Lymph Gland. A filtering device found in the course of a lymphatic channel. Not a true gland because it does not produce a liquid, it merely contains lymph which has come from the blood.

Mal. Grand and petit mal are the two forms of epilepsy.

Malnutrition. Faulty nourishment. Often loosely used as synonymous with undernourishment.

Medulla. One of the nerve centres of the brain.

Meibomian Gland. A grease-producing gland of the eyelid. (After the anatomist, Meibomius.)

Metabolism. The term applied to all the chemical activities of a living cell.

Microbe. See *germ*.

Molar. A grinding tooth.

Mucus. A slimy material produced by the salivary and other glands. The adjective is mucous, pertaining to mucus.
Myopia. Short sight.

Neuritis. Inflammation of a nerve.
Neurone. A complete nerve cell with all its processes.
Nit. The egg of the head louse.
Nitrogen. One of the gases of the atmosphere.

Optic, Optical. Pertaining to the eye.
Ossicles. Small bones, especially those of the middle ear.
Oxidation. The chemical process of combining something with oxygen.
Oxygen. One of the gases of the atmosphere.

Palate. The partition between the nose and the mouth.
Pancreas. A digestive gland which is also an endocrine organ.
Parasite. A living creature which lives in or upon another. (From the Greek, one who eats at the table of another.)
Pasteurization. The process of heating milk (without boiling it) to kill germs without destroying the vitamins. Named after the French scientist, Louis Pasteur.
Pectoral Girdle. See *shoulder girdle.*
Pediculosis. The state of being infested with lice. (Latin, *pediculus*, a louse.)
Pelvic Girdle. See *hip girdle.*
Pelvis. See *hip girdle.* (Latin, a basin.)
Perflation. The action of the wind in blowing into a room.
Perspiration. The action of sweating.
Phagocyte. One of the white corpuscles of the blood which acts as a scavenger. (Greek, an eating cell.)
Pharynx. The space at the back of the nose and mouth.
Physiology. The science which treats of the function or working of the body.
Pituitary Body or *Gland.* An endocrine organ situated in the skull beneath the cerebrum.
Plasma. The liquid part of the blood.
Plenum. A space filled with air, the opposite of a vacuum.
Premolar. A grinding tooth standing in front of the permanent molars.
Protein. A food material and a constituent of protoplasm.
Protoplasm. Living matter.

Pylorus. A ring of muscle, the contraction of which prevents the passage of food from the stomach into the small intestine. (Greek, a gate-keeper.)
Pyorrhœa. A disease of the gums.
Pulmonary. Pertaining to the lungs. (Latin, *pulmo* lung.)

Quarantine. A period of isolation imposed upon those who have been in contact with an infectious disease. (Italian, *quarantina* = forty days, formerly the usual period of quarantine for all diseases.)

Rectum. The last part of the large intestine.
Respiration. The action of breathing.
Retina. The light-sensitive lining of the eye.
Rickets. A disease of the bones caused by lack of vitamin D.

Sacrum. A large bone at the base of the vertebral column. Forms part of the hip girdle.
Sclerotic Coat or *Sclera.* The tough outer coat of the eyeball.
Scurvy. A disease of the blood vessels caused by lack of vitamin C.
Sebaceous Gland. An oil-producing gland of the skin, commonly opening into a hair follicle.
Secretion. The liquid product of a gland.
Serum. A liquid derived from the plasma of the blood. Commonly that taken from an immunized animal for the inoculation of a human being.
Shoulder Girdle. The incomplete ring of bone joining the arms to the trunk.
Sodium Chloride. Common salt.
Spinal Column. See *vertebral column.*
Spinal Cord. Part of the nervous system enclosed within the vertebral column.
Spine. See *vertebral column.*
Squint. Having the two eyes turned in different directions. Also known as strabismus.
Stye. An abscess on the eyelid.
Suprarenal Glands. See *adrenal glands.*
Suspensory Ligaments. Minute fibres attaching the lens of the eye to the ciliary body.
Sweetbread. See *pancreas.*

Synapse. The place where the dendrons of two neurones come into contact with one another. (Greek, in contact with.)
Synovial Fluid. The lubricating liquid inside a joint.
Synovial Membrane. The membrane lining a joint, the cells of which produce the synovial fluid.

Tannin. A substance, found in tea, which hardens protein.
Tendon. The fibrous end of a muscle by means of which it is attached to a bone.
Theine. A stimulant contained in tea, identical with, or closely related to, caffeine.
Theobromine. A mild stimulant, contained in cocoa, related to caffeine.
Thorax. The chest.
Thyroid Gland. An endocrine organ situated in the neck.
Tonsils. Masses of tissue, similar in structure to lymph glands, situated at each side of the back of the mouth.
Tourniquet. A bandage which can be tightened. Used to prevent bleeding from a wound.
Toxin. A poison produced by germs.
Trachea. The windpipe.

Ultramicroscopic Virus. A germ of the type too small to be seen under the microscope.
Urine. The liquid waste product of the kidney.

Vaccination. A method of rendering people immune to small-pox by administering special lymph derived from a calf. (Latin, *vacca* = a cow.)
Vaccine. A preparation of dead germs used to produce immunity against an infectious disease.
Vacuum. A space from which air has been removed. The so-called vacuum system of ventilation involves the extraction of air from a building but does not produce an actual vacuum.
Vein. Any blood vessel carrying blood towards the heart.
Vena Cava (pl. *Venæ Cavæ*). One of the two principal veins of the body.
Ventricles. The lower chambers of the heart, discharging blood into arteries.
Vertebra (pl.-*æ*). One of the spinal bones.
Vertebral Column. The collection of vertebræ commonly known as the backbone.

Vertebrate. An animal which has a vertebral column.

Villus (pl.-*i*). A finger-like projection from the wall of the small intestine.

Virulence. The power of a germ to give rise to disease.

Vitamin. An accessory food factor necessary for proper nutrition, but not yielding energy to the body like the proteins, fats and carbohydrates.

Vitreous Body. The transparent, jelly-like material contained in the back part of the eyeball. (Latin, glassy or transparent.)

White Matter. The parts of the brain and spinal cord where the axons of neurones are congregated, giving rise to a white appearance.

INDEX

ABDOMEN, 62.
Accidents, 280-293.
Adenoids, 50, 273.
Adrenalin, 104.
Adrenals, 104.
Air, composition of, 300.
  vitiation of, 301.
Alcohol, 133-137.
  action of, on brain, 135.
  — on internal organs, 135.
  — on stomach, 134.
  content of some beverages, 133.
  effect of, on reflex actions, 135.
    on temperature, 134.
  food value of, 134.
Alcoholism, chronic, 136.
Alimentary canal, 60-70.
  movement in, 62.
  regions of, 61.
  summary of, 70.
Amœba, 4.
Amœboid movement, 5.
Anæmia, 233.
Ankle, sprained, treatment of, 287.
Antibodies, 239.
Antitoxin, artificial, 246.
Anus, 67.
Aorta, 41.
Appendicitis, 68.
Appendix, 68.
Aqueous humor, 184.
Arm, fractured, first-aid treatment of, 285.
Artery, 41, 42.
  connected with muscle, 32.
Artificial respiration, 289.
Aspiration, ventilation by, 303.
Astigmatism, 195.
Audiometer, 210.
Auditory nerve, 206.
  deafness, 213.
Auricles, 39.
Axon, 90.

BACTERIA, 237.
Balance system of ventilation, 308.
Bathing, facilities for, in schools, 156.
Beverages, 127-137.
Bile, 70.
Bites, insect, treatment of, 283.
Bladder, 75.
Blepharitis, 197.
Blind children, education of, 200.
  — law relating to, 336.
Blood, 36-47.
  corpuscles, 36.
Body, growth and development of, 113-116.
  heat, production of, 160.
  — regulation of, 160.
Bone, nature of, 25.
Bones, 13-26.
Bowel, large, 62, 67.
  normal action of, 71.
  small, 62, 66.
Braille, 200.
Brain, 84.
  action of alcohol on, 135.
  deafness, 214.
  nerve centres of, 86.
  position of, 17.
Breathing, 48-59.
  mechanism of, 55.
Bronchi, 52.
Bronchitis, 53.

Building of schools, plans for, 294-299.
Bunion, cause of, 164.
Burns, treatment of, 282.

Cæcum, 68.
Caffeine, 131.
Calcium, 126.
Calorie, 119.
Capillaries, 41, 42.
Carbohydrates, 118.
Carbon dioxide, 7, 33.
Cardiac, *see* Heart.
Cartilage, 15, 23.
  nature of, 26.
Cataract, 197.
Cells, 4-12.
  activities of, 6.
  human, 11.
  specialization of, 9.
Cerebellum, 87.
Cerebrum, 86.
Chest, 18.
Chicken-pox, 253.
Child guidance clinics, 327.
  welfare centres, 326.
Children, correct posture of, 165-167.
  diseases of, 233-293.
  faults in clothing of, 163.
  faults in footwear of, 164.
  law relating to, 336-339.
  meals for, 141.
  — conduct of, 145.
  — premises for, 143.
  medical inspection of, 321.
  — law relating to, 337.
  physical training for, 168.
  physically and mentally defective, education of, 311-320.
  training in cleanliness of, 154.
Choroid coat of the eyeball, 180.
Ciliary body, 181.
Cinema, effect on eyesight of, 191.
Circulation, general, 41.
  in the lungs, 41.
Classrooms, equipment of, 298.
  lighting of, 188.
  structure of, 297.
Cleanliness, training children in, 154, 232.
Clinics, ante-natal, 325.
  child guidance, 327.
  post-natal, 326.
  school, 325.
Cloakrooms, equipment of, 298.
Clothing, cleanliness of, 159.
  faults in, 163.
  nature of, 162.
  purpose of, 160.
Cochlea, 205.
Cocoa as article of diet, 132.
Coffee as article of diet, 131.
Cold, common, 272.
Collar bones, 22.
Concussion, 288.
Conduction, in cells, 8.
  in nervous system, 80.
  of heat, 161.
Conjunctiva, 179.
Conjunctivitis, 197.
Constipation, 70.
  causes of, 72.
  effects of, 73.
  prevention of, 72.
Consumption, 259.
Contraction, 8.
  muscular, 32.
Convection, 304.
Convulsions in major epilepsy, 277.
Co-ordination, training in, 35.
Cornea, 180.
Corpuscles, red, 36.
  white, 37.
Cranium, 17, 86.
Crèche, 326.
Cretin, 103.
Cripples, schools for, 317.
Crypts in intestine, 66.

Deaf children, education of, 217.
— — law relating to, 336.

Deafness, 213.
Deformities, 235.
caused by rickets, 152.
Dendron, 90.
Dental, *see* Teeth.
Dental caries, 229.
Dentine, 218.
Dentist, school, 324.
Dermis, 77.
Desks, suitable for children, 165.
Development, phases of, 116.
physical, 113.
of young, 107.
Diabetes, 104.
Diaphragm, action of, in breathing, 57.
Dick test for scarlet fever, 254.
Diet, age and, 120.
balance of, 119.
criteria of adequate, 140.
essentials of, 138.
typical, for a day, 140.
Dietetic, *see* Food.
Diffusion, ventilation by, 303.
Digestibility of foods, 149.
Digestion of food, 60-73.
Diphtheria, 251.
course and symptoms of, 251.
exclusion from school for, 251.
Schick test for, 252.
treatment of, 246.
Diseases, caused by malnutrition, 122-125.
chronic, 257-264.
classification of, 234.
functional, 275-279.
infectious, 241-256.
— table of information regarding, 244-245.
minor respiratory, 272-273.
of the ear, 214.
of the endocrine organs, 102-104.
of the eye, 197-198
of the skin, contagious, 265-271.
of the teeth, 228-232.
Dislocations, first-aid treatment of, 285.
Drinking fountain for school cloakroom, 156.
Drowning, 289.
Ductless glands, 101.

Ear, 202-217.
diseases, 214.
disorders, 212.
drum, 204.
external, 203.
— deafness, 213.
foreign body in, 292.
function of, 205-209.
hygiene of, 209-212.
internal, 205.
— deafness, 213.
— organ of position in, 207.
middle, 204.
— deafness, 213.
— disease, 214.
structure of, 202-205.
Education, *see* Schools.
Electric heating of schools, 310.
Emergencies, 280-293.
Endocrine organs, 101-105.
Energy, production of, 7, 33.
Epidermis, 77.
Epilepsy, 276.
major, 276.
minor, 277.
treatment of, 278.
Epileptic children, education of, 278.
— — law relating to, 336, 337.
Ergosterol, 125.
Eustachian tube, 204.
Excretion of waste products, 74-79.
Exercise, conduct of, 168.
results of, 33, 168.
value of organized, 34.
Eye, 174-201.
as a camera, 174.
diseases, 197.
disorders, 193.

Eye—(*continued*).
foreign body in, 292.
function of, 184-187.
hygiene of, 187-193.
muscles, 178.
strain, 196.
structure of, 174-184.
Eyeball, 180.
in the orbit, 178.
Eyelashes, 177.
Eyelids, 176.

Face, 17.
Fainting, 287.
hysterical, 275.
Fallopian tubes, 109.
Fat in body, 77.
Fatigue, 168.
causes of, 168.
muscular, 33.
symptoms of, 169.
treatment and prevention of, 169.
Fatness caused by pituitary defect, 102.
Fats in food, 118.
Feeding of school children, 138-146.
— law relating to, 146, 337.
Fermentation in stomach, 66.
Fertilization, 110.
Fevers, infectious, *see* Infectious fevers.
Finger-nails, care of, in school, 158.
First-aid box, 293.
treatment, 280-293.
Flat foot, 21.
Follicle, hair, 78.
Food, 117-126.
daily requirements of, 119.
digestion of, 60-73.
improper, causing malnutrition, 149.
insufficient, causing malnutrition, 150.
Food—(*continued*).
kinds of, 117.
requirements of different ages, sexes and conditions, 121.
uses of, 117.
Foods, composition of common, 138.
dietectic value of some, 142.
digestibility of, 149.
good for the teeth, 224.
Foot, bones of, 21.
Footwear, faults in, 164.
Foreign bodies in ear, eye and throat, 292.
Fractures, 283.
dangers of, 284.
first-aid treatment of, 284.

Gall-bladder, 70.
Games, value of organized, 34.
Ganglia, sympathetic, 88.
Germ diseases, groups of, 240.
spread of, 239.
German measles, 250.
Germs, 236.
body's defences against, 238.
disease produced by, 238.
host and, 237.
virulence of, 237.
Glands, 68.
ductless, 101-105.
Meibomian, 179.
salivary, 69.
sebaceous, 78.
sweat, 77.
tear, 179.
Glycogen, 33.
Goitre, 103.
Grey matter, 91.
Gristle, *see* Cartilage.
Growing pains, 261.
Growth, 113.
at different ages, 114.
seasonal, 115.
sex and, 115.
Gullet, 52, 64.

HÆMOGLOBIN, 36.
Hair, 78.
care of, 158.
Hearing, 202-217.
defective, education of children with, 216.
maintaining normal, 209.
mechanism of, 206.
standards of, 211.
tests of, 210.
— six-foot rule in, 212.
Heart, 38.
action of, 39.
beat, 42.
chambers of, 39.
disease, rheumatic, 261.
muscle, 28.
valve, 40.
Heat conduction, 161.
Heat-stroke, 288.
Heating of schools, 308-310.
Height, increase in, at different ages, 114, 141.
Heredity, 328-330.
Hip girdle, 22.
Hormone, 101.
pituitary, 102.
sex, 110.
Hygiene, definition of, 1.
of the ear, 209-212.
of the eye, 187-193.
of the school, 294-327.
of the teeth, 223-232.
personal, of children, 154-159.
teaching of, 331-335.
— — methods of, 331.
— — principles of, 331.
Hypermetropia, 195.
Hysteria, 275.
treatment of, 276.

IMMUNIZATION, 247.
Impetigo, 265.
Incubation period of infectious fevers, 241, 245 256.
Infection, control of, 255.
spread of, 239.
Infection (*continued*).
spread of, in fevers, 244, 256.
— in tuberculosis, 258.
Infectious fevers, age of onset of, 244, 256.
— carriers of, 247.
— convalescence after, 243.
— general characteristics of, 241.
— points of importance in, 255.
— relapses after, 243.
— sequels to, 243.
table of information regarding, 244-245.
— treatment of, 243.
Influenza, 272.
Inhibition, 96.
Inoculation, 247.
Insect stings and bites, treatment of, 283.
Insulin, 103.
Intervertebral discs, 15.
Intestine, large, 62, 67.
small, 62, 66.
Iodine, 126.
Iris, 175, 181.
Iron, 126.
Irritability of cells, 9.
— in nervous system, 97.
Isolation for infectious fevers, 245, 246, 256.

JOINT capsule, 23.
movement, 24.
structure of, 23.
tuberculosis of, 259.
types of, 25.

KIDNEYS, 74.

LACTIC acid, 33.
Larynx, 57.
Law relating to children, 336-339.
— to verminous children, 271, 337.

Lens of the eye, 175, 183.
— power of accommodation of, 185.
Lenses, action of, 184.
Lice, head, 269.
Life, nature and characteristics of, 3-12.
Ligaments, 15, 23.
Light and action of lenses, 184.
Lighting of classrooms, 187.
Limbs, 19.
Lime, 126.
Liver as digestive gland, 70.
as food-storing organ, 67.
Lungs, 53.
circulation in, 41.
exchange of gases in, 54.
tuberculosis of, 259.
Lymph, 45.
Lymphatic channels, 46.
glands, 46.
— tuberculosis of, 259.

Mal, *see* Epilepsy.
Malformation, 235.
Malnutrition, 147-153.
chief causes of, 150.
dietetic factors causing, 148.
general factors causing, 147.
methods of dealing with, 153.
Meals for school children, 141.
— conduct of, 145.
— premises for, 143.
Measles, 248.
course and symptoms of, 248.
exclusion from school for, 249.
treatment of, 250.
Medical inspection in schools, 321.
— law relating to, 337.
— results of, 323.
officer for schools, 324.
record form, 322.
work in schools, teacher's part in, 325.
Medulla, 87.
Meibomian glands, 179.
Menstruation, 110.
instruction regarding, 335.
Mental apathy as sign of under-nourishment, 151.
backwardness caused by rickets, 153.
Mentally defective children, education of, 318.
— law relating to, 319, 337, 338.
Microbes, 237.
Milk, 128-131.
accredited, 130.
dangers of, 129.
food value of, 128.
graded, 129.
pasteurized, 131.
provided in schools, 129.
spread of tuberculosis by, 258.
tuberculin tested, 130.
Mineral salts, 125.
Mouth, 49, 63.
Muscle sense, 100.
Muscles, 27-35.
arrangement of, 30.
connections of, 32.
contraction of, 32.
— movement produced by, 28.
involuntary, 27.
parts of, 28.
uses of, 30.
voluntary, 27.
Muscular weakness as sign of under-nourishment 151.
Myopia, 193.

Nerve, 88.
activity, conscious, 94.
cells, 80.
centres, 82.
connected with muscle, 32.
Nervous system, 80-100.
disease of, 235.
Neurone, 88.
connecting, 90.
motor, 89.
sensory, 90.
Nits, 270.

Nose, care of, 158.
foreign body in, 292.
smell-cells in, 99.
structure of, 48.
Nucleus of cell, 5.
Nurse, school, 324.
Nursery, day, 326.
school, 326.

OPEN-AIR schools, 313.
— organization of, 314.
— results of, 316.
Optic nerve, 176.
Orbit, 176.
eyeball in, 178.
Organs, definition of, 11.
internal, action of alcohol on, 135.
— position of, 111.
Ovaries, 108.
Over-eating causing malnutrition, 148.
Overgrowth caused by excess of pituitary hormone, 102.
Ovum, 109.
Oxygen, 7, 33.

PALATE, 49.
Pallor as sign of undernourishment, 151.
Pancreas as digestive gland, 69.
as endocrine organ, 103.
Papillæ, 98.
Parasitic diseases, 236-274.
Pediculosis, 269.
Pelvis, 22.
Penis, 110.
Perflation, ventilation by, 303.
Phagocytes, 38, 238.
Pharynx, 52, 63.
Phthisis, 259.
Physiology, summary of, 113.
Pituitary body, 102.
Plasma, 36.
Playground, equipment of, 298.
Plenum system of ventilation, 307.
Poisoning, first-aid treatment of, 290.
Poisons, corrosive, 291.
non-corrosive, 290.
Pores, 77.
Posture, correct, 165-167.
maintained by muscles, 30.
Print suitable for reading, 189.
Proteins, 117.
Protoplasm, 3.
Protoplasmic bud, 5.
Pseudopodium, 6.
Pulmonary artery, 41.
veins, 41.
Pulse, 42.
Pupil of the eye, 175, 181.
Pylorus, 65.
Pyorrhœa, 230.

QUARANTINE for infectious fevers, 245, 246, 256.

READING, correct position for, 189.
suitable print for, 189.
Rectum, 62, 67.
Reflex actions, conditioned, 95.
effect of, alcohol on, 135.
simple, 92.
Reproduction, 106-110.
Reproductive organs, female, 108.
male, 109.
Respiration, artificial, 289.
Respiratory system, 48-59.
Rest and sleep in schools, 172.
Retina, 181, 182.
Rheumatic fever, 261.
heart disease, 261.
sore throat, 261.
Rheumatism, 260-264.
treatment of, 262.
Ribs, action of, in breathing, 56.
structure of, 18.
Rickets, 125.
nature and causes of, 151.
symptoms of, 152.
Ringworm, 266.

SACRUM, 15, 22.
St. Vitus' dance, 261.
Saliva, 69.
Salivary glands, 69.
Salt, common, 125.
Sanitation in schools, 298.
Scabies, 268.
Scalds, treatment of, 282.
Scarlet fever, 253.
Dick test for, 254.
Schick test for diphtheria, 252.
School children, *see* Children.
Schools, artificial lighting of, 188.
clinics in, 325.
closure of, in epidemics, 254.
dental service in, 232.
equipment of, 297-299.
facilities for drinking and washing in, 156.
for blind children, 200.
for cardiac and rheumatic children, 262.
for crippled children, 317.
for deaf children, 217.
for epileptic children, 278.
for mentally defective children, 318.
for mothers, 327.
heating of, 308-310.
law relating to, 336-339.
lighting of, 187.
meals provided in, 144.
medical service in, 321-327.
milk provided in, 129.
open-air, 313-317.
physical training in, 168.
plans for building of, 294-297.
rest and sleep in, 172.
sanitation in, 298.
ventilation in, 300-310.
Sclerotic coat of the eyeball, 180.
Scrotum, 109.
Scurvy, 124.
Sebaceous glands, 78.
Sebum, 78.
Semen, 109.
Semi-blind children, education of, 199.
Sensation, 97.
Senses, special, 97.
Sex hormones, 110.
teaching, 334.
Sexual development arrested through pituitary defect, 102.
Shock, treatment of, 282.
Shoulder blades, 22.
girdle, 21.
Sight, long, 195.
short, 193.
— education of children with, 198.
Sight-saving class, 199.
Sight testing, 191.
Skeleton, 13-26.
Skin, 76.
contagious diseases of, 265-271.
corrosive poisons on, 292.
function of, 78.
Skull, 16.
Sleep, 170-173.
in schools, 172.
lack of, causing malnutrition, 147.
notes on, 173.
physiology of, 170.
quality of, 170.
quantity required at different ages, 171.
Small-pox, 252.
vaccination for, 253.
Smell, 99.
Sodium chloride in body, 125.
Sound, nature of, 205.
Spermatozoon, 109.
Spinal cord, 88.
curves, 15.
Spine, 13.
Splint, 284.
Sprains, treatment of, 286.
Squint, 196.
Staffordshire schools, 295.
Stammering, 278.
treatment of, 279.

Stings, insect, treatment of, 283.
Stomach, 62, 64.
  action of alcohol on, 134.
  fermentation in, 66.
  juice, 65.
Stye, 197.
Sunstroke, 288.
Suprarenal glands, 104.
Sweat glands, 77.
Sweetbread, 69.
Swimming baths, 158.
Sympathetic chains, 88.
  ganglia, 88.
Symptoms of infectious fevers, 244, 255.
Synapse, 91.
Synovial fluid, 23.
  membrane, 23.
System, 11.
  circulatory, 36-47.
  digestive, 60-73.
  nervous, 80-100.
  reproductive, 106-110.
  respiratory, 48-59.

Tannin, 132.
Taste, 98.
Taste-buds, 98.
Tea, as article of diet, 132.
Tear gland, 179.
Teeth, 218-232.
  development of, 222.
  diseases of, 228-232.
  hygiene of, 223-228.
  — training in, 232.
  inspection of, 227, 232.
  methods of cleaning, 225.
  permanent, 221.
  proper use of, 223.
  structure of, 218.
  temporary, 220.
  types of, 219.
  uses of, 222.
Temperance teaching, 333.
Temperature, normal, 161.
Tendons, 28.
Testis, 109.
Theine, 132.
Thigh, fractured, first-aid treatment of, 285.
Throat, foreign body in, 293.
Thyroid gland, 103.
Thyroxin, 103.
Time table, arrangement of, 169, 189.
Tissues, 11.
Tongue, 63.
  structure of, 98.
Tonsils, 51.
  enlarged, 273.
Tourniquet, 281.
Toxins, 238.
Tuberculosis, 257-260.
  nature of, 258.
  prevention and cure of, 260.
  spread of, 258.
  symptoms of, 259.

Unconsciousness, 287-290.
  in epilepsy, 276.
Under-nourishment, signs of, 151.
Urine, 74.
Uterus, 109.

Vaccination for small-pox, 253.
Vacuum system of ventilation, 308.
Vagina, 109.
Valve, heart, 40.
Varicose veins, 45.
Vein, 39, 44.
  connected with muscle, 32.
Vena cava, 42.
Ventilation, 300-310.
  artificial, 307.
  natural, 302-306.
  — devices used in, 304.
Ventricles, 39.
Vertebra, 14.
Vertebral column, 13.
Villi in intestine, 66.
Viruses, ultra-microscopic, 237.

Vision, 174-201.
  defective, education of children with, 198-201.
Vitamins, 122-125.
Vitreous body, 183.
Vocal cords, 58.
Voice, 57.

WASHING, facilities for, in schools, 156.
Water, 127.
Weight, increase in, at different ages, 114, 141.
White matter, 91.
Wind, action of, in ventilation, 303.
Wind-pipe, 52.
Word deafness, 214.
Worms, 273.
Wounds, first-aid treatment of, 280.